THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science,

HALIFAX, NOVA SCOTIA.

VOLUME XI.

1902-1906.

HALIFAX:
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CONTENTS.

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PART I.

SESSION OF 1902-1903.

WITH 18 PLATES.

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CONTENTS.

TRANSACTIONS

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SESSION OF 1902-1903.

IS THERE COAL UNDER PRINCE EDWARD ISLAND?—BY HENRY S. POOLE, D. SC., F. G. S., F. R. S. C.

(Read 18th May, 1903.)

The great activity of late in the coal trade of Nova Scotia and a continuing demand have enhanced the value of coal prospects, and have stimulated inquiry and search in every direction in which rock structure may suggest, not only to the geological student and the miner, but to the promoter and speculator, a possible deposit of coal.

Among the regions in which it is supposed hidden extensions of the productive measure may exist, the Gulf of St. Lawrence is included. For a long time it has been looked on as overlying the major portion of an original coal field of which remnants are found fringing its waters to the south and east, containing, perhaps, in isolated sections, workable seams of coal.

Prince Edward Island lying in the southern part of the Gulf, offers a means of access to any underlying deposits, although the superficial strata of the Island, of later age than the coal measures of Nova Scotia, show of themselves no indication of what is beneath, and are regarded as a cloak covering hidden treasures.

In Prince Edward Island the expectation in this direction can only be met by actual search in depth, and this may best be done by bore-holes in places carefully selected. Matters have gone so far as to receive attention from the Canadian Geological Survey Department, and an experienced officer* has revisited the Island with that object in view. With this feature of the question it is not proposed to deal in this paper, which has for its object only a review of such suggestions as the structure of the several geological formations developed in the neighbouring regions seem to present.

It is no part of this paper to consider the correlation of the several series of deposits both above and below the productive coal measures of Nova Scotia. The terms used are those which appear most convenient, and are the same as those employed, in the Reports of the Geological Survey of Canada, by Mr. Hugh Fletcher in his papers on the surrounding districts. Although disputes have arisen over these terms, and the propriety of their selection has been questioned, they have this advantage,—they leave no doubt as to the sequence of the several groups of strata to which they relate. Whether they be correlatively correct or not, is of no moment in this connection. The terms used are taken to mean as follows:—

Permian.—Strata chiefly reddish sandstones with a base of conglomerate showing at New Glasgow and elsewhere; a few small seams of coal and bituminous shales. The upper members more friable and more easily eroded.

Coal Measures.—Strata containing workable beds of coal with shales and fireclays chiefly black and grey, and sandstones generally grey in colour.

Millstone Grit.—Strata conformably underlying the productive measures, including coal seams, and grit often coarse and reddish in colour.

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*Dr. Ells, Summary Rept. Geol. Surv. Canada, for 1902.

Carboniferous Limestone.—Limestone associated with gypsum, sandstones, marls, and local conglomerate; fossil shells, common; coal seams, thin, few, and irregular.

Carboniferous Conglomerate.—Basal beds often indicating induration.

Devonian.—Including the plant beds of Riversdale, N. S., and Little River, N. B. The Albert shales containing the characteristic Psilophyton.

In this inquiry, the material that is available and from which, on consideration, a conclusion may be derived, consists of :—

(*a*) The rock formations surrounding the Gulf of St. Lawrence;

(*b*) The character of the deposits containing workable beds of coal in the measures bordering the area;

(*c*) And the evidence of soundings in the Gulf which are recorded on the shipping charts.

It is assumed that in Pre-Cambrian days the outline of eastern North America took shape much as it is now, and at the same time the salient features as seen to-day of that part of the continent were established. The edge of the continental shelf was determined and gave limit to the movements which since then have, in large measure, been epeirogenic in character. Synchronous with the alternations to which the region has been subjected along the eastern edge of the shelf, a line of marked weakness branched westward from the margin, where it is sharply deflected eastward to the south of Newfoundland and the Grand Banks. The latter are essentially a part of the continent, though at present under water and in touch only at the Virgin Rocks, which are, it is believed, of Pre-Silurian age.*

If we view the several formations involved in this region as units, it will appear that the amount of local disturbance each has undergone is somewhat proportionate to the respective age: the Permian least, the Millstone Grit moderately, while older

*It is not questioned that the Grand Banks have been largely added to by moraine matter of the Glacial epoch, and have had accretions deposited from icebergs, but on a shallow rock base, an integral part of the continent.

series have suffered much more. The disturbances that did occur, being in proportion to the continental movements, and local, were principally due to settlements under the weight of an increasing mass on an imperfectly denuded and uneven floor of deposition of a previous cycle.

The principal physical features seem to have been retained during the several epochs in the area of the Gulf and its surroundings. Ever since Silurian time the Gulf was an area of depression in its relation to more ancient rocks, although at some periods occupied by more recent and more easily eroded deposits, elevated for a time above the general level of the ocean. During the recurring cycles since Pre-Cambrian erosion gave it shape, depression, deposition, elevation and erosion, regional in action, have been each in turn at work, not always fully replacing and not always fully undoing, the results attained by the opposing force. We see this in the marginal remains and in the islands of the Gulf.

In very early stages of the earth's history direction seems to have been given to the subaerial erosion by the line of fracture that branched westward from the continental edge during periods of elevation which then established a system of drainage for a large area. The same fracture affected the foldings consequent on settlement of the deposits and the oscellations of the plateau.

The geological history of the region it is assumed may be thus summarized :—It was fashioned by deep erosion while Cambrian depositions were proceeding, and folded by lateral pressure which produced parallel ranges along the edge of the continent, the continuity of which was disturbed by the branch fracture to which reference has already been made. Of the lines of partial relief to the lateral pressure, one was established on the south side of the coastal range in New Brunswick, thence it was diverted by the fault spoken of to a course nearly due east and west, leaving on the north the highlands of Dalhousie Mt. in Pictou Co., and those near Cape George in Antigonish. It thus formed the southern rim to the Gulf region. Thence renewing their original direction the oro-

genic movements proceeded through the highlands of Inverness to join the great fault of the St. Lawrence Valley and the Gulf, and give an easterly margin to the area in question.

With the geological cycles that occurred prior to the Carboniferous era, we are not particularly concerned, beyond noting the more and more marked persistance, as time rolled on, of the dominant features, and the establishment then of systems of drainage which have continued to the present day, e. g., that through the Cabot Strait and between St Paul's Island and Cape North, which must have been long continued for the erosion to cut down rocks as hard as these Pre-Cambrian, to such profound depths, 2000 feet or more below the level of the sea, itself some 1400 feet below the eroded top of the mountain plateau. Then, too, the Pre-Carboniferous erosion cut through the Pre-Cambrian rim to the Gulf area, where the ancient break had occurred at the deflection between Cape George and Cape Mabou. In the waters between these capes, soundings show a submerged ridge, a remnant of the mountain range. A similar old time denudation, doubtless, gave direction to the rivers of Pictou. Yet again we have another opportunity to measure the work of Pre-Carboniferous erosive agents in these time-defying rocks. The eastern end of the coastal range bordering the Bay of Fundy has its present termination in Caledonia Mountain, but when the land stood at a higher level, the range extended further to the eastward and beyond the passage across it of the existing rivers, the Petitcodiac and Memramcook. Of the extension beyond these rivers, remnants of former peaks project through later formations at Lutz Mountain, Colhoun's and McManus's Mills. These modern rivers have their beds cut in rocks of Millstone Grit, Carboniferous Limestone and Albert Shales, deposits here occupying a broad valley previously eroded across the range of old rocks by Pre-Devonian streams, the predecessors draining the extensive country lying to the north of the range.

To what depth this great Pre-Devonian valley was eroded is not known, but bore-holes in search of oil in the Albert Shales

have proved it to be over 1000 feet below the tide, and thus presumably comparable in character to the broad valley in Cabot Strait that drained the St. Lawrence region when the continent was elevated far above its present level. That the continent has stood vastly higher than it now does, there can be no doubt, and to convert the present estuary of the great river and the Gulf into a valley with a flowing stream capable of eroding its bed, would require a general elevation of not less than 2,500 feet, and possibly still more.

The Pre-Carboniferous erosion, which was of excession magnitude, left for subsequent depositions a platform that, through all after changes, has retained much of its original horizontality. Nor has it been broken, except locally, by fractures of secondary importance, and then only to a very limited extent. The cycles preceding the Carboniferous, supplied the erosion that gave shape to Nova Scotia as a peninsula and formed the great bays of the coast, of which some still show above the present shoreline remains of the Lower Carboniferous deposits that evidently encircled and covered much of this and neighbouring lands. Remains of these deposits are to be found in the bays of St. Margaret, Chedabucto, Fourchu, Gabarus, Lorraine, Mira, the Bras d'Or, St. Ann, Aspy, St. Lawrence, etc.

Circumstances changing, and a new cycles entered on, there must have followed a depression of corresponding magnitude and conditions favorable for the deposition of the bay and other deposits, the massive limestones and gypsums beds which are spread over an extent of country some four hundred miles in length.

After an epecyclical period and lessened disturbances which left large districts of these later deposits still exposed to denudation, a series of sedimentations set in, which in time culminated in strata associated with the productive coal measures.

We have now reached the crux of the matter, and have to consider how wide-spread were the conditions favorable to the deposition of coal seams, and in what districts did those con-

ditions exist. Was the Gulf in any part an upland region during the coal measures period ?

We do know from a study of the Pictou coal field that there were limits and parts where no workable coals were laid down.* In Cumberland County, also, the Geological Survey has demonstrated the gradual and final substitution of non-bituminous for bituminous deposits. A close study on the western coast of Cape Breton, it is believed, will show like conditions there,—basin-shaped districts which never were parts of one coal sheet continuous over the Gulf area. The districts of coal measures now found isolated above the shore line, were in some cases probably not separated by faults, but further exploration is necessary to prove this. An examination of the admiralty charts suggests that a surmise may fairly be made of the rock structure which underlies part of the Gulf. The islands tell us something, and we know that a well defined anticline, bringing to the surface Carboniferous Limestone strata, extends from Shepody Mt., at the head of the Bay of Fundy, towards Wallace, parallel with the Cobequid range and the series of great folds in the gold-bearing rocks of the Cambrian. This Wallace anticline is not seen to the eastward, but its continuation, hidden under Permian strata, is suggested by the presence of an elevated ridge shown by soundings to range east of Pictou Island and southeast of Cape Bear of Prince Edward Island. I venture to go still further a-field and to regard that the basal rocks of the Magdalen Island, also of Carboniferous Limestone age, and which, in comparatively recent times, were much more extensive than they now are, extended, as indicated by the soundings, parallel to the Cape Breton coast near to Prince Edward Island, owing their origin to a folding contemporary with the Wallace anticline. Within the shelter of these ridges possibly were the conditions alone favorable for the accumulation of coal in seams of workable thickness.

Prince Edward Island and the major part of the Gulf area lie outside the fold.

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* The Pictou Coal Field, Trans. N. S. Inst. Sc., vol. 8, 1893.

Sections and Analyses of Nova Scotia Coals.—By Edwin Gilpin, Jr., A. M., Ll. D., F. R. S C., etc., etc.

(Read 18th May, 1903.)

I venture to submit the following sections and analyses of Nova Scotia coals. The paper refers only to seams which are at present being worked, and the sections and analyses have all been recently measured and made. While the true value of coals may be better determined by ultimate analyses and practical tests for coking, evaporative power, etc., these results may be of interest to the members of the Institute.

Sections of Nova Scotia Seams.

Pictou County.

Intercolonial Coal Mining Company, Drummond Colliery, Westville:

Main Seam, section taken 200 feet below No. 14 lift:

	Feet.	Inches.
Top coal (coarse)	2	2
Fall coal	3	8
Fire-clay	0	5
Top-ply coal	2	0
Bench coal	5	2
Stone	0	5
Bench coal	2	8
Stone	0	5
Bottom coal	3	0
Total	19	11

Main Seam at No. 4 Slope, top level:

	Feet.	Inches
Coal (coarse)................	1	2
Fire-clay	0	5
Coal	3	6
Pyritous parting	0	1
Coal	2	10
Total	8	0

Acadia Coal Company:

Acadia Main Seam at south level sinking, Acadia Colliery, Westville:

	Feet.	Inches.
Top coal	0	10
Fall coal	3	6
Soft carbonaceous shale	0	3
Coal	4	4
Coal (coarse)	2	0
Coal (bench)	3	6
Total	14	5

Deep Seam, at No. 4 balance, 1900 feet level, Albion Mines, Stellarton:

	Feet.	Inches.
Coal	4	4
Coal (coarse)	3	8
Coal	12	0
Total	20	0

Third Seam, south level, 2000 feet from slope, Albion Mines, Stellarton:

	Feet.	Inches.
Coal	9	0
Coal (coarse)	0	9
Coal	3	3
Total	13	0

McGregor Seam, Albion Mines, Stellarton:

	Feet.	Inches.
Coal (Fleming Seam)	4	2
Coal, coarse (parting)	5	0
Coal	6	0
Hard shale with ironstone nodules (not persistent)	0	6
Coal	15	0
Total	30	8

Six Feet Seam, Vale Colliery, Thorburn:

This seam does not maintain a regular thickness, varying from 3 to 6 feet, within short distances. Thus in No. 1 balance, north side, it runs from 3½ to 5 feet clean coal. In Nos. 2 and 3 balances, same district of the mine, it runs from 4 to 6½ feet of good coal. In the sinking it shows from 6 to 7 feet of good coal.

Nova Scotia Steel and Coal Company:

G. Mackay Seam, Marsh Colliery:

	Feet.	Inches.
Coal (coarse)	0	1
Coal	3	0
Coal (coarse)	0	4
Stone	0	1
Coal	0	4
Total	3	10

CUMBERLAND COUNTY.

Cumberland Railway and Coal Company, Springhill:

No. 2 (or West) Slope:

	Feet.	Inches.
West Seam,—west side	8	0
Aberdeen Seam (extension of West Seam)	8	0
Under Seam (split extension of Middle [or East] Seam)	4	0
Over Seam, (split extension of Middle [or East] Seam)	4	0

No. 3 (or North) Slope:

	Feet.	Inches.
North Seam,—west side	8	3
North Seam,—east side	4	0

Canada Coals and Railway Company, Joggins :

	Feet.	Inches.
Coal	3	0
Clay	1	2
Coal	1	6
Total	5	8

Minudie Coal Company, Minudie Colliery, River Hebert :

	Feet.	Inches.
Coal	1	7
Fireclay	0	8
Coal	1	9
Total	4	0

Strathcona Coal Company, Strathcona Colliery, River Hebert :

Milner Seam (?):

	Feet.	Inches.
Coal (with parting)	2	6

Jubilee Colliery, Maccan River.

Coal	2	0

Maritime Coal Company, Chignecto Colliery, Maccan :

	Feet.	Inches.
Coal	2	6
Fire-clay	1	6
Coal (with parting)	5	6
Total	9	6

Cape Breton County.

Gowrie and Blockhouse Collieries, Port Morien :

Gowrie Seam :

	Feet.	Inches.
Coal	4	10

Nova Scotia Steel and Coal Company, Sydney Mines:

Main (or No. 1) Seam at Princess Pit:

	Feet.	Inches.
Coal	5	4

Lloyd's Cove (or No. 2) Seam:

	Feet.	Inches.
Coal	2	3
Clay	0	2
Coal	0	6
Clay	0	0½
Coal	3	3½
Total	6	3

Main (or No. 3) Seam at Sydney Pond:

Coal	4	7½

Sydney Coal Company, North Sydney Colliery, Indian Cove:

No. 3 (or Indian Cove) Seam:

	Feet.	Inches.
Splint coal	0	3
Coal	4	3
Total	4	6

Dominion Coal Company:

Phalen Seam, at Caledonia Colliery, Glace Bay:

	Feet.	Inches.
Splint	0	0½
Coal	5	11½
Parting	0	0
Coal	1	6
Total	7	6

Phalen Seam, at Dominion No. 2 Colliery:

	Feet.	Inches.
Coal	7	6

Phalen Seam, at Dominion No. 3 Colliery:

Coal	5	3
Splint	0	$0\frac{1}{2}$
Coal	3	0
Total	8	$3\frac{1}{2}$

Phalen Seam, at Reserve Colliery:

	Feet.	Inches.
Coal	8	0

Phalen Seam, at Dominion No. 1 Colliery:

	Feet.	Inches.
Coal	8	0

Harbor Seam, at Dominion No. 2 Colliery:

	Feet.	Inches.
Splint	0	1
Coal	6	5
Total	6	6

Harbor Seam, at International Colliery:

Splint	0	1
Coal	5	8
Total	5	9

Victoria County.

Cape Breton Coal Mining Company, New Campellton:

Main Seam:

	Feet.	Inches.
Splint	0	4
Coal	4	0
Total	4	4

INVERNESS COUNTY.

Inverness Railway and Coal Company, Broad Cove:

Seven Feet Seam:

	Feet.	Inches.
Coarse coal	0	7
Splint	0	4
Coal	6	1
Total	7	0

Port Hood Coal Company, Port Hood:

Main Seam:

	Feet.	Inches.
Splint	0	2
Coal	6	8
Splint	0	2
Total	7	0

Mabou Coal Mining Company, Mabou:

No. 1 (or Seven Feet) Seam:

	Feet.	Inches.
Coal	1	6
Shale parting	0	1
Coal	1	6
Shale parting	0	1
Coal	2	0
Clay	0	1
Coal	1	9
Total	7	0

No. 2 (or Eight Feet) Seam:

	Feet.	Inches.
Shaley Coal	1	0
Coal with shale	1	5
Clay parting	0	2
Coal and shale	0	6
Soft fire-clay	1	0
Coal	3	3
Fre-clay	0	3
Coal, hard	0	9
Coal	3	6
Total	11	10

No. 3 (or Fifteen Feet) Seam:

	Feet.	Inches.
Shaley coal	2	0
Coal	3	6
Clay parting................	0	1
Shaley coal	0	6
Coal	2	6
Shale parting	0	2
Coal	1	3
Shale parting	0	1
Coal	4	0
Total	14	1

No. 4 Seam:

	Feet.	Inches.
Coal	2	6
Canneloid coal..............	1	6
Coal	2	0
Total	6	0

Analyses of Nova Scotia Coals.

Pictou County.

	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur.	Moisture.
Intercolonial Main Seam..	25.73	65.36	8.20	1.10	.72
Marsh Colliery..........	35.43	55.48	9.99	1.26	..
Vale Colliery	28.80	55.30	14.50	.92	1.40
Acadia, Westville........	28.09	60.77	9.99	1.24	1.15
McGregor Seam	28.37	61.13	10.50	1.43	*
Cage Pit Seam -	29.88	59.34	10.78	.87	*
Third Seam	30.69	53 34	15.97	1.37	*
Acadia Mines, average....	26.80	62.20	9.70	1.15	1.30

*Moisture included in volatile matter.

CUMBERLAND COUNTY.

	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur.	Moisture.
Joggins	40.89	48.33	10.78	5.72	..
Minudie	36.15	52 45	9.60	5.04	1.80
Strathcona	37.36	52.25	10.39	4.47	..
Chignecto	39.75	48.75	9.95	6 02	1.55
Springhill (straight in levels):					
No. 2 Slope, east side	34.09	59 25	6.66	1.14	..
" " Minto Seam	37.44	56.85	5.71	2.36	..
" " Aberdeen, east	32.30	60.49	7.31	1.02	..
" " " west	31.08	58.30	10.62	2.62	..
No 3 Slope, west, 3800 ft.	35.36	59.72	4.92	.96	..
" " 2600 ft.	33.42	58.58	8.00	1.12	..
" " east, top, 2600 ft.	36.44	58.54	5.02	1.10	..
" " east, top, 2600 ft.	36.05	57.38	6.57	2.38	..
Average analysis Springhill coal	34.51	58.64	6.85	1.59	..

CAPE BRETON COUNTY.

Sydney Mines Main Seam	36.27	57.05	4.76	2.01	1.92
Lloyd's Cove Seam	36.11	57.25	2.83	3.14	3.81
Lingan Main Seam	34.05	59.97	3.68	1.71	2.32
Phalen Seam:					
Dominion No. 1	31.25	60.75	6.95	1 88	1.05
" No. 2	32.45	61.45	5.25	1.99	.85
" No. 3	31.65	62.20	5.00	1.67	.95
Caledonia	30.85	62.05	6.40	2.32	.70
Reserve	30.75	63.70	4.65	1.81	.90
Harbor Seam, at International	37.20	56.90	5.10	3.11	.80
Gowrie Seam, at Gowrie and Blockhouse Col.	36.00	57.70	5.20	3.82	1.10

VICTORIA COUNTY.

	Volatile combustible matter.	Fixed carbon.	Ash.	Sulphur.	Moisture.
New Campbellton Main Seam	35.50	51.55	8.95	5.50	4.00

INVERNESS COUNTY.

Port Hood Main Seam	34.67	56.39	8.94	1.10	..
Mabou, 7 Feet Seam	35.90	53.30	8.70	1.88	2.10
" 8 " "	34.25	56.40	6.95	1.85	2.40
" 15 " "	37.50	51.20	9.05	5.77	2.25
5 " "	35.65	49.55	11.95	5.20	2.85
" Average of seams	35.82	52.61	9.16	3.67	2.40
Broad Cove, 7 Feet Seam....	45.55	47.09	7.36	4.91	..

Geology of the Moose River Gold District, Halifax County, Nova Scotia.*—By Prof. J. Edmund Woodman, S. D., *School of Mining and Metallurgy, Dalhousie University, Halifax, N. S.*

(Read 18th May, 1903.)

Contents.

*The third of a series of papers on the gold-bearing rocks of Nova Scotia; extracted and altered from a thesis accepted for the Doctorate of Science at Harvard University in 1902, entitled "Geology of the Moose River district, Halifax county, Nova Scotia; together with the pre-Carboniferous history of the Meguma series." The first two papers appeared in the American Geologist, 1904, vol. xxxiii.

INTRODUCTION.

Location.—The settlement of Moose River Mines lies in lat. 44° 58′ 55″ N., long. 62° 56′ 40″ W.; and is 37.5 miles northeast (true meridian) from Halifax. Its rocks form a portion of the upland, or Cretaceous peneplain, here very flat. The surface over many square miles of this region is so even that Sphagnum abounds, with moist soil below; and for long distances a well-driven pick will strike bedrock anywhere. On the north barrens extend for several miles: to the other side lies more timbered country, becoming swampy toward the Tangier granite with numerous lakes. Natural exposures are few, and the true structure is discoverable only by means of underground workings or surface trenches.

The settlement was made, as many others have been, merely by clearing the timber off the level land and damming up a small stream, Moose river, for power. Mining has been carried on in a small way for many years, but no shafts have been sunk below 500 feet. In the course of exploration, numerous shallow pits and trenches have been cut, exposing the bedrock across the strike of the strata. Many hundreds of feet of trenches were opened for me in 1899, in the course of economic development. A few quarries, located as they all are in rather critical parts of the field, afford excellent opportunities for study. The surrounding country is evenly covered with drift, nowhere very

thick and in many places less than a foot deep; and outcrops for several miles are no more abundant than within the limits of the settlement itself.

Extent and topography.—The main settlement extends rather more than half a mile east and west, and a third of a mile north and south (pl. 1, fig. a). One mile west a district locally called "West Mine," (pl. 1, figs. a, b), has been opened superficially for economic purposes; and here also it has been possible to do some detailed work, which has aided in interpreting the structure of the main field. Little could be made of the intimate structure in either part of the district without the aid of subsurface workings, which range from shallow trenches and larger quarries to shafts three hundred feet deep. No really deep sinking has ever been done here.

The topography of the region is that of a plain with very slight relief. The drainage is weak, although low falls are numerous. Lakes abound. The general direction of the main streams is northwest to southeast. Moose river, from which the settlement takes its name, runs roughly south from Caribou, seven miles north-northeast of the Moose River mines, where it has expanded into several lakes. Between the two localities it has a wandering course, often broadening into linear lakes, and in places almost lost in swamps. At the northwest corner of the settlement the river has been dammed to supply one of the crushers, and again at the north for a similar purpose.

From the pond first mentioned, west for a mile or more the surface is fairly even, rising to a height of twenty-five feet above the river, but for the most part without distinct hills or ridges. The disposition of the drift accounts for much of the slight irregularity. East of the river the land rises twenty-five feet in five hundred, then very gradually for a mile. The south side of the district, however, was largely a swamp until 1898.

Division into units of area.—Like most of the proclaimed gold districts of the province, Moose River has been divided by the Department of Works and Mines into *blocks*, composed of

areas; each of the latter being 250 feet north and south by 150 feet east and west. Thus each of the six blocks composing this district contains 1,000 areas, and measures 7,500 feet east and west in fifty areas' width, and 5,000 feet north and south in twenty areas' length. The main settlement comprises a few areas in blocks 1 on the north and 4 on the south (pl. 1, fig. a, and pl. 2). "West Mine" is in block 6 on the north, and south of it lies block 5 (pl. 1, fig. a).

Much trouble has arisen in the study and economic development of gold-bearing properties in various parts of the province, because the early surveys were carelessly made, and always by magnetic meridian; and in many cases either the date or the declination has been omitted from the map. The declination has changed steadily, and in many districts resurveys have detected errors in the older work, and the present area lines may follow neither magnetic nor true meridians. This discrepancy is especially marked where the lines have been run parallel and perpendicular to the general strike of the rocks, as here. The declination at Moose River in 1897 was approximately 22° 15′ W. The north-south lines run 5° west of this, or about 27° 15′ west of true north. In this paper all bearings are referred to magnetic north.

Method of approach to subject.—The survey of the Moose River district formed part of an investigation into the pre-Carboniferous history of the gold-bearing series. The spot was selected for detailed study, partly because it appeared to be typical of the series as a whole in many ways, and yet unique in a few features—and in just those features favorable to the study of the veins. I recognize that certain large problems in Nova Scotian geology can never be solved until close, painstaking, detailed work has been done on critical sections; and while the detail in this paper may at first appear excessive, the study has been made deliberately, in the hope that it may lead to more detailed work elsewhere in the series.

The field studies occupied parts of several seasons. When the first survey was made, in 1897, no maps of the district had been published; but within a few months the mining map by Mr. E. R. Faribault appeared [Geol. surv. Can., doc. no. 646; scale 1 : 6,000]. I am much indebted to this for the positions of certain veins which have not been worked since the present study began, and for checks upon certain other features. The map in this paper is more detailed than is customary, even in large-scale mining maps, in its attempt to locate the axes of the several folds; and has the benefit of a number of excavations which were unfortunately not opened when the earlier plan was published. It is a pleasure to note that, while pl. 2 differs in many details from the government map, the later work confirms in the main the general results of Mr. Faribault's survey. This last is to be expected; as his painstaking work has invariably resulted in valuable maps of the anticlinal domes.

Inasmuch as this is a field study, petrographic and chemical aids have been employed only as far as was necessary for the main purposes of the paper; and many interesting problems involving their use have been neglected. It will be noticed also that the larger theoretical questions are not included in the following pages, except for a partial summary at the end. This is because the length of the paper would be increased unduly, were they treated in full; and the alternative is to be followed of presenting a discussion of the general problems arising from the study, in subsequent detached papers.

Nomenclature.—Throughout more than a half-century of study of the gold-bearing series, no distinct geological names have been used for it and its subdivisions. Almost simultaneously with this paper another has been published, proposing a remedy (Am. Geol, vol. xxxiii); and the nomenclature of that paper will be employed by me in this and subsequent contributions to the geology of the series. The gold-bearing series as a whole is there called the *Meguma series*; the lower, quartzite, or gold-

bearing division is named the *Goldenville formation*; and the upper or black slate division, the *Halifax formation.*

Below is a list of terms used in the present paper, which might otherwise be misunderstood by some, because of newness or the local meaning employed.

Angular—(1) An irregular spur from a stratified vein, or (2) a vein striking nearly or quite with the strata, but intersecting them in dip. The first meaning is in part local, as in some other places these veins are called "feeders" or "robbers."

Barrel—A corrugation of stratified veins, and of strata adjacent to them, usually on the plunge of a domed anticline.

Break—Fault.

Lead—Stratified vein.

Pocket—A restricted portion of a lead or other vein, locally highly enriched.

Regular—In the plane of stratification.

Roll—Generally a synonym for "barrel."

Surface—Glacial drift.

Whin—Sandstone or quartzite in this series.

:00 or :01.—1900, or 1901, dates.

Acknowledgments.—This research had its beginning in a small study made for and with Professor N. S. Shaler of Harvard University; and throughout the continuance of this and of other studies arising from it, he has aided it in every way, so that my indebtedness to him is greater than to anyone else.

The help derived from Mr. Faribault's map has been mentioned. Thanks are due also to Mr. B. F. Pearson and Mr. J. K. Pearson, upon whose property much of the detailed work was done, and who gave every facility for it; and to owners and workers of the other properties in the district.

PART I.—STRUCTURE.

DATA FOR STRUCTURAL INTERPRETATION.

Absence of fossils.—No fossil remains of any description have been discovered in the rocks of Moose River. The only appearances suggestive of them are some concretions which protrude from the surface of a quartzite ledge on area 132, block 1. These have weathered less than the rest of the rock, through the possession of a firmer cement. They appear as ovoid projections ranging up to three inches in length, two in width and three-quarters in height. Frequently stratification bands can be seen to pass through them, but these are faint. The weathering has left the surface of the concretions rough.

In the slide they show no trace of organic origin. Their appearance differs little from that of the other quartzites of the district, except in a slightly coarser texture and more abundant cement; characteristics which decrease outward from a center, and doubtless the concretionary growth is a function of them. Two thin sections show grains of quartz cemented by silica and calcite, with the usual secondary minerals, described later. The grains are so situated as to leave no room for an organic nucleus, now perhaps lost, but both specimens show an inorganic nucleus. The cementation has centered around a few coarse grains of sand, about twice the diameter of the other grains. In the vicinity of these is a comparatively dense network of secondary minerals, chiefly dark ones such as chlorite, biotite, and particularly a dense amorphous iron oxide. Wherever the grains of quartz are unusually large, there is a tendency to this increased density; but it centers chiefly around one spot.

Lithological horizons.—Of rock horizons, only one can be found which, by reason of its distinctness and continuity, might be used throughout the region as a datum plane. This is the slate belt containing the Jo. Taylor belt of leads. Unfortunately the structure is such that this one is not visibly repeated across

the strike; and furthermore, the outcrops and artificial exposures are not so placed as to make the exact delimitation of this horizon easy.

Interbedded veins, and distribution of strikes and dips.—Most of the interpretation of structure rests, then, upon two series of data—the attitude of the stratified veins, and the distribution of strikes and dips in the sediments. In small areas and for short distances, recognition of definite horizons in the strata is also possible. The distribution, attitude and characteristics of the bedded veins serve well within certain limits; but beyond a fault these criteria may occasionally fail, especially if the displacement be large, or the veins near a point where they die out or cut across the strata to another horizon, as they do in a few places. Yet veins are frequently the only horizon markers available in measuring a fault. Taken in connection with the distribution of strikes and dips of the sediments, and the lithological character of the strata on the hanging and foot-walls of vein belts, they form part of a fairly secure group of data.

SEDIMENTS.

General distribution.—North of the settlement, beginning two or three areas beyond the Copper lead, the rocks are chiefly quartzite for nearly three miles. Here and there thin slate strata are intercalated, but the proportion of argillaceous material is small. South of the mines, starting at the third or fourth tier of areas south of block 1, quartzite again stretches for several miles. The exact proximal limits of these whin* zones cannot be given, on account of the few natural outcrops and the absence of artificial openings; but the margin of error is small.

Between these limiting whin areas is a broad belt characterized by lustrous black slate, often somewhat schistose; essentially

*This quartzite is called "whin" by miners throughout the province. The term, used throughout the gold mining part of the province for sandstones, arenaceous slates and quartzites was originally employed by Hutton in Scotland, to designate certain sheets of trap, and in Cornwall still has a similar meaning.

different from the slate of the Halifax formation, which is well exposed on the road north from the mines. There are quartzite strata within this zone, but they are comparatively few and narrow. In them, as in the more abundant ones to the north slate lenses with rounded edges are occasionally found. It is the extent of this slate belt, at least 1,500 feet wide across the strike, which constitutes one of the unique features of the district. All the ore-bearing veins are situated in it, even though many of them lie at the contact of slate with thin strata of quartzite.

The plunging of the folds east and west is not sufficient to bring the bordering quartzites of the north and south around the ends of the anticlines—at least, within the limits of the survey.

Characteristics: slates.—The argillaceous material varies from a soft lustrous slate to one that is as hard and dense as the best roofing slates. In both the composition is chiefly kaolin, finer in the former, and somewhat lighter colored in the slide. Most of the characteristics seen in thin section are metamorphic. The color in the field is due largely to the same cause, but the firmness has for its primary source the texture of the mass, allowing the metamorphic changes to act differently in different cases. On the whole, the coarser the slate the less it has been shattered by cleavage.

Characteristics: quartzites.—The coarser sediments grade imperceptibly into the pelites in places, but in the slide a sharper line of demarcation is usually present than would be expected. The quartzites have as their chief constituent fine and well rounded grains of quartz. The cement is partly secondary silica, but so much calcite is present that it is difficult to see in some specimens what can be the origin of the granular gleam characteristic of fresh quartzite surfaces, and highly developed in the psammites of Moose River.

No distinctly felspathic material was seen in the slides, and little kaolin in any but the finer whin. There is, however, a considerable amount of muscovite and biotite. While some of

the mica is evidently secondary, other pieces, especially of biotite, show by their rounded outline and their relation to the quartz grains that they are clastic.

Contacts of strata.—The discontinuity of strata has been mentioned. This is as marked in a small as in a large way; for there are many lenticles of slate in the whin, from a few inches in length to less than one, the ends of which are sometimes well defined and rounded, but more often vague and serrate. In no case has the microscope shown a local deposit of slate thinning out to an edge. The upper and lower contacts are smoother where not folded; but even these are frequently sinuous, merely from almost microscopic differences in deposition. Under the influence of folding and cleavage, the strata and laminæ have assumed very complex relations.

FOLDS.

Position of the two main anticlines.—One of the features in which Moose River differs from other gold districts of Nova Scotia is in being situated, not on one dome, but on three. It has been stated that the rocks of the Meguma series lie in persistent and roughly parallel folds, the axes of which run northeast to east. Two of the anticlines pass through this field (pl. 1, fig. a, and pl. 2). The more northerly has a direction of N. 60° E. (true) at the east end of the main settlement, and N. 69° E. (true) at its west end. The other runs N. 65° E. (true) on the east, and N. 74° E. (true) on the west. Thus both are converging westward at an angle of 5°.

Union of anticlinal axes westward.—The north axis can be traced eastward through Fifteen Mile Stream settlement, apparently dying out five miles northwest of Goldenville. The south axis passes eastward through Beaver Dam and Ragged Falls gold districts, running parallel with the other at a distance of two to two and a half miles from it, and continues farther east through Stillwater to Country Harbor. There it is lost in a fault of large horizontal displacement, although the Seal Harbor anti-

cline is almost certainly a continuation of it. The eastward course of the two folds does not come further into this study. Westward, however, they are of special interest, on account of their continued convergence and final union a mile west of the settlement (pl. 1, figs. a, b). The combined anticline stretches westward through Mt. Tom, probably to Waverley. Its point of bifurcation is partly a matter of estimate, as outcrops are few and little trenching has been done; but enough observations are possible to give reasonable accuracy.

Stratigraphic position of Moose River district.—The only datum plane in the series available for broad structural study is the contact between the Goldenville and Halifax formations. North of Moose River lies a broad zone of the latter, and many observations can be made between the two. South of the mines there is no belt of black slate north of the Tangier granite, in such line that a section through Moose River would intersect it.

On the road north from the settlement, although outcrops are numerous at the roadside and in the surrounding barrens, it is difficult to get the structure with certainty. All the exposures are of quartzite, and the weathered faces and superficial parts easily reached with a hammer rarely show slate laminæ. The whin itself is too uniform to have visible stratification planes. Such observations as are possible give steep north dips up to the edge of the upper formation. Two miles west of the mines a traverse north is possible under better conditions. Here the dips vary somewhat, averaging 75° N., and giving a thickness of 16,730 feet. The Moose River anticline plunges westward throughout this region, and to the eastward lower and lower strata lie against its axis at the surface. If 75° N. be assumed for the average dip of the Goldenville beds north of the mines, as seems reasonable in view of observations at the traverse to the west and three miles to the east of the settlement, the lowest exposed strata on the main north anticline lie 16,900 feet below the base of the Halifax formation.

South from Moose River, at least one anticline intervenes between the mines and the edge of the upper formation; and calculation based upon that traverse is rendered still more uncertain by the scattered distribution of such outcrops as are structurally valuable.

Details at "West Mine."—It is at "West Mine" that the union of the two anticlines occurs. This region contains, besides two or three natural exposures, two trenches and several shallow shafts. The location of the axis before and after branching, and of the openings, is shown in pl. 1, fig. b. On areas 187 and 188 the rocks show no sign of a double axis, where visible. By estimate, the farthest point west at which the two axes should be in the least separate, is 64 feet west of the east side of area 189, and 156 feet south of its north end. As a matter of fact, there must be a zone eastward for some hundreds of feet, in which the division is accomplished, and before it can be said that there are two distinct axes. The few natural exposures are somewhat disturbed, but farther east two axes are plain.

The data at West Mine are not so full as in the settlement. The only sources of continuous observation would be trenching across the strike and cross-cutting underground. The two trenches already referred to were in disuse at the time of my study, and gave only intermittent views of the bedrock. The "surface" or drift varies in depth from one foot up to eight or ten. The north end of the northern trench lies in area 214, six feet east and 94 south from its northwest corner. The rocks here have a high north dip, but were not well exposed in 1899. The cut runs 77 feet S. 25° E., to a lead. South of this lie two or three feet of compact quartzite, with a smooth contact; then fourteen feet of dark slate interspersed with siliceous layers, ending against more whin with a "rolling" or corrugated footwall contact. These last strata strike N. 80° E. and dip 64° N. The same attitude is found 29 feet south, where the rock has been trenched for many feet along the strike to expose a bedded vein. Thirty-three feet south again is the north end of an eight-

foot belt of slate, on which a shaft has been sunk. Between these stations the rock appears to be quartzite, and south of the slate three feet is the hanging wall of another narrow band of slate. In area 187, next south of 214, the shaft which has been mapped lies over a six-foot belt of veins, the belt being crumpled slate. The strike here is N. 87° E., the dip 84° N. The trench shown on the map runs S. 42° E. Along this 175 feet south is the first vein with a south dip. Thirty-three feet farther is a second, and thirty-one feet south of it a third. The exposures were in such condition in 1899 that the degrees of dip could not be measured accurately, but they were high. The bedrock was only obscurely visible anywhere along this trench. From such indications as could be found, and from questioning those who had dug the ditch, the estimate was made that the axis lies about 125 feet from the north end of the trench. It strikes east and west, and the estimate here agrees almost exactly with that given earlier, from data a mile to the eastward. Throughout the traverse of the region the rocks show a local crumpling and contortion unlike anything seen in most of the districts, but such as might be expected to accompany the division of an anticlinal axis, in alternating competent and incompetent strata. For a considerable distance north and south, such outcrops or prospect holes as have been found from year to year show dips away from the axis.

The minute details of this commercially unimportant field have been given, because they throw light upon some problems in the main settlement. For the location of the strata, veins and structures in the main part of the field, pl. 2 can be used throughout the remainder of the discussion of structure.

Location of axes in main district.—In the eastern part of the region the structure, reduced to its lowest terms, is that of two east and west anticlines, slightly diverging eastward, the north fold plunging west and the south one east. Between them, owing to the abundance and peculiar distribution of the slate strata, there has been developed a local anticline, which

appears to die out westward almost within the limits of the field: and which quite certainly ends on the east within a short distance, although another has been found seven miles from the mines. This is one of the unique features of the area, because of the opportunity it offers for the study of the growth of folds; and is made possible by the presence of the broad horizon of slate instead of the alternation of narrow well-defined bands of slate and quartzite characteristic of the other domes.

The more northerly of the two main anticlines starts east from West Mine with its axis taking a probable direction of N. 86° E. Where it crosses Moose river it has a strike of N. 89° W. The more southerly fold starts east with a strike of N. 87° W., and at the west end of the main field lies N. 84° W. This gives an eastward divergence of 5° to the axes. Where they cross the stream they are approximately 525 feet apart. The vicissitudes of faulting are described elsewhere. It may be recorded here, however, that east of the westernmost main fault the north anticlinal axis does not change its strike; east of the middle fault it lies for most of its way N. 86° W., probably turning northeast somewhat, as do the beds to the north; and east of the third main fault it starts N. 88° E., but soon turns to N. 82° E. The directions of this and the other six axes, at the extreme east end of the district, are estimates based upon observations immediately west and some distance east. The south anticline starts directly east from the west fault; but runs northward somewhat, influenced but not intersected by the middle fault, then strikes S. 87° E., to the east fault. Beyond this the axis is sinuous for nearly 500 feet, finally straightening out in a direction N. 87° E. Thus the axes diverge eastward at 5° here, also. The distance between them is the same as at the west end—525 feet.

Lack of outcrops makes the position of the synclinal axis between these folds problematical, west of the west fault. Inasmuch, however, as it is very definitely located everywhere else, the position assigned, based upon data immediately to the east,

cannot be far wrong. East of this fault the nearest outcrops of opposite dips are only twelve feet apart, so that the axial line can be given with great accuracy. East of the middle fault the axis is estimated with reference to a definite horizon which appears on both sides of the break,—the Jo. Taylor belt of leads —combined with certain other less definite data. East of the east fault, also, exposures define the position of the line closely. It will be noticed that here the distance to the south anticlinal axis is much less—45 feet—than in any place to the west.

To understand the growth of the middle fold, it will be necessary to state in detail the data available for determining the structure. For this purpose, the rocks will be considered in four divisions—*i*, west of the west fault; *ii*, between this and the middle fault; *iii*, west of the east fault; and *iv*, including the east end of the field.

Division i: attitude and character of strata.—Exposures in division i are few, compared with the rest of the region. West of the river the only shaft is that on area 66, supposed to be on a continuation of the Britannia belt. The dip of the skids is about 50° S. The rock on the dump consists largely of an argillaceous quartzite, grayish green in color and highly lustrous. Mingled with this is a compact, shiny black slate. It was impossible to descend the shafts at any of the visits. North to the bend of the river is a continuous outcrop along the stream bed. It is all quartzite, having only here and there laminæ by which to get the attitude. The two records on pl. 2 sum up all the knowledge that can be gained without excavation. The strata at the more southerly station strike from N. 85° E. to E.—W., according to the precise spot of observation.

East of the stream the land is low and somewhat swampy toward the north. On areas 133 and 168 is a ledge of much weathered quartzite, but it is impossible to be sure of its attitude. It lies along the line of probable westward continuation of the north anticline, and doubtful evidence points to a north

dip on the north side, and a south dip on the south; but this was not considered in plotting the axis on the map. Several outcrops lie a few feet north of the Alex. Taylor lead, all but two, which have been recorded, being of doubtful value for structure. These two exposures are quartzite, so that there is no slate on or near the surface north of the lead just mentioned; but this is not surprising, as the slate rarely stands out well under erosion. Northeast of the shaft near the center of area 132, is a ledge from which the concretionary "fossils," already described, were collected. This is also whin, coarse in places and with an indeterminate but distinctly low south dip. The Alex. Taylor lead is important because, although the deepest shaft is only forty feet down on a 35° surface dip, the lead flattens out considerably in that depth. The next data come from the Britannia, which gives an average dip of 45° S. A small trench on area 69 showed in 1899 six belts of leads, all with a fairly steep south dip, one measured as 67°. In 1901 a belt of rather erratic veins had been opened on areas 68 and 69, to a depth of 170 feet. The dip of the sediments varies considerably in that distance, through irregular "rolling" of the beds; but it is safe to call it on the average 70° S.

No other exposures are met north of the Touquoy crusher except a number of leads in a drain on the east side of area 32, observable only in 1899. They all have steep north dips, some probably vertical; but the depth open to observation was too slight to make sure of that. These leads, on account of similarity in attitude, interval and composition, are taken to correspond to the Moleskin and leads south of it in the trench on area 30; and to the south, leads with a south dip, very like the Smith and those near it, have been seen when the drain was fresh. Finally, a bedded vein occurs at the south corner of the Touquoy crusher, vertical and in vertical strata; and south of this are three south dips, on area 33.

Division i: interpretation of structure.—The obvious interpretation of these data is given in the section on pl. 3. The

north side of the north anticline is fairly to be inferred from observable steep dips east of the fault. South of this axis the dips are low for some feet, increase to 35° at the surface in the Alex. Taylor lead but are still low below; then steepen steadily to 70°, with an average of about 60°. South of the synclinal axis the dips are known to be steep; and from veins in the trench on area 32, and known east of the fault, in divisions ii and iii, a probable average of 70° is obtained. South of the south anticlinal axis, the dips begin at 90° and run out to at least 70°. Farther east they are lower.

Two interesting features are shown in this section. First, the folds are all unsymmetrical, but irregularly so. The axial plane of the north anticline dips 60° S., that of the other two folds 85° S., giving an overturn to the north in all. Second, the north anticline is not normal and simple, but compound, having on the south side very low central dips, and a distinct bulge about one-third of the distance to the synclinal axis. How far west this bulge extends there is no means of knowing, because the country is undeveloped; but eastward it grows into a distinct third anticline, clearly defined, but evidently lying on the side of the north fold. Although not fully developed in division i, this bulge is divisible into an anticline with an axis dipping 53° N., and a syncline whose axis dips 64° N.

Division ii: north anticline.—In division ii the most northern dip visible is that of No. 7 lead, between 70° and 75°. The slate belt extends at least a hundred feet farther north, according to those who worked this part of the district in earlier years; and by estimate some distance beyond. Between No. 7 and the Little North, the rock is still largely quartzite, slate increasing in proportion southward. Even as far as the Big North whin is found to some extent. The dips north of the axis are sufficiently represented on the map—low near the center and increasing outward. The anticline has a comparatively flat top, as can be seen well in the quarry on area 131.

Division ii: westward pitch of north anticline.— Many years ago the Big North was stoped out on the crest of the fold westward on a plunge, the work going somewhat farther than the shaft at the north end of area 132, or about 200 feet. Later the crown was broken down in part, and the present quarry made. This plunge, characteristic of most of the gold districts of Nova Scotia, begins on the east side of area 131 at 9.5° W., and becomes 12° on the west side of the same area. How much higher the angle grows it is impossible to say ; for the west fault cuts off both the Big North and Serpent leads, and it has never been proved that the leads west of the break are the same.

Division ii: subsidiary fold, pitching east.—South of the anticlinal axis in areas 130 and 131, the only dip except on the plunge comes from a trial shaft in the center of area 130. Here slate was encountered, almost flat, but dipping south enough to give an average of 5° S. According to this, the axial plane dips 70° S. in this part of the fold. At the south end of these areas is the Archibald vein. This dips 48° S. at the surface; but it does not lie directly in the bedding, as witness the discordance of its strike with all the others near. The Bruce is, however, "regular" or interstratified. From it to the south end of areas 70 and 71 the structure, revealed only by the quarry, gives folds merely foreshadowed in division i. The dips are south for sixty to eighty feet south of the Bruce belt (pl. 7 fig. c); but the strike is erratic, varying from the normal—almost east and west—at the north, to N. 20° E. in one place at the south. For thirty feet farther the dips are slightly northward, the strikes varying from N. 10° W. to N. 30° W. Here, then, is a local syncline, apparently dying out westward, and running east to the fault. That part of division i (pl. 3) to which it corresponds, is the flattening out of the south dips in the Alex. Taylor lead and vicinity. The best estimate of the dip of the axial plane makes it 83° N.

The anticline south of this trough corresponds to the change from low to high dips toward the Britannia, in division i. It

plunges eastward, as shown by the curved strike of the Jo. Taylor belt, and of the strata at the east end of the quarry, immediately north of the anticlinal axis. The Taylor belt is found on that side also, but does not reach the surface in the unexcavated part. The angle of pitch is difficult to measure or estimate, but is about 15° E. All this part of the field is slate, except here and there a stratum of quartzite, such as overlies the Jo. Taylor belt to a thickness of four or five feet. This belt of leads takes part in the synclinal folding immediately to the north. The axial plane of the anticline appears to dip 85° N.

Division ii: south main fold.—The synclinal axis south of the quarry is measurable to within a few feet, for the two nearest outcrops of opposite dip are scarcely twelve feet apart, measured directly across the strike. This axis is continued from west of the west fault, and its plane dips 83° S. The rocks to the south dip much as in the corresponding zone on areas 30 and 171, east of the middle fault. The angles are all high to the south anticlinal axis, whose plane dips 82° S. Thence as far south as the Root Hog the dips vary from 50° S. near the axis to 70° at the lead just mentioned. The rock is slate from the Jo. Taylor belt to the south end of the trench on area 970, block 4, except for a few quartzite strata of no importance. Indeed the small exposure south of the trench, and one near the south end of area 930, block 4, indicate that the slate belt extends at least 650 or 700 feet south of the south anticlinal axis. This trench is one cut in 1899 expressly to develop the structure of the rocks and the distribution of the leads.

Division ii: relation to division i.—A comparison of the cross sections of these two divisions (pls. 3, 4), shows that in ii there is beginning to form a distinct subsidiary anticline on the flat side of the northern fold. It is probable, judging from the distribution of dips in and near the quarry on area 70, that the local syncline does not extend to the fault on the west, and its axis has been drawn with this belief. West of the fault there is no syncline, and this one begins as a definite sag fifty or one

hundred feet east of the break, becoming more marked eastward. It will be noticed that the axes of the local folds dip in opposite directions from those of the main ones; as is to be expected if division ii is a development of division i.

Division iii: north anticline.—In division iii, the northernmost outcrop is a vein on areas 227 and 228. It is doubtful whether this is parallel with the stratification; and as it is some distance beyond the main field, it will not be considered either in map or section. Leads east of the middle fault which have always been regarded as continuations of the Copper and Little North have been worked, in some cases to a depth of 200 feet. From the character of the gangue, and the adjacent sediments, there is little doubt that those two and the Big North are represented in this division. The dips become noticeably lower toward the axis, as is characteristic of the north anticline, which has everywhere a full top and rounded north side. Between the Big North, called the North Sutherland at its east end, and the quarry on areas 73 and 74, there is only one exposure. This is a small pit on the line between areas 126 and 127, where the rock is slate, lying flat. As far as can be learned from those who prospected this zone in earlier years, the strata are almost entirely slate, resembling that of division ii north of the Jo. Taylor belt.

Division iii: subsidiary compound fold.—In the quarry on areas 73 and 74 is a horizon corresponding to part of the larger quarry to the west. On the south the hanging wall lead of the Jo. Taylor belt outcrops, overlain by the usual whin stratum. The foot-wall lead of this belt forms much of the floor of the excavation. On the north side the strata dip north at angles varying from 20° to nearly 40°. On the south the dip is 30° to 45° S. Between is a small but distinct synclinal sag (pl. 8, fig. a). This, then, is the perfection of the fold prophesied in division i and shown in an incomplete form in division ii. Not only has an anticline been formed on the side

of the large one, but this has itself been made compound by the sinking of a syncline on its summit. On area 75 a small quarry shows this puckering to a slight extent. In this case, however, the dips on the north side are very low, not over 10°. The same condition obtains in a tunnel which runs from the floor of this quarry, eastward under the road to a new quarry on area 76.

Division iii: south anticline.—South of the Jo. Taylor belt, the dips vary on the same horizons, steepening westward and becoming lower eastward. Thus the Dreadnaught slate belt, which has a dip of 45° S., south of the quarry, has only 20° one area to the east. The Dry belt, which dips 80° N. at the north end of area 30, declines to 50° and 35° eastward. The Moleskin changes from 70° to 35° at the extremities of its developed portion. The bearing of this may be seen by comparing with these dips the distribution of dips along the horizon of the Jo. Taylor belt east and west of the middle fault. From such comparisons it appears that both the middle and south anticlines plunge eastward steadily, the former rapidly, the latter at a lower angle.

Little is to be said of the south dips on the south anticline. The Comstock has 60° S. near the east end, becoming somewhat steeper westward. The Root Hog was opened in 1899, and has not been developed far enough to show a diminution of dip.

Division iii: details from trenches.—The best data for parts of this division have been obtained from two trenches cut in 1899 on areas 30 and 71, to develop the structure. The Jo. Taylor belt consists of several leads, of which the hanging and foot-wall ones are easily distinguishable. The belt averages seven feet in thickness. The hanging wall lead is exposed east of the middle fault in a small pit at the end of the east embayment of the quarry, area 71 ; in the smaller circular pit to the north, and again at the south end of the north trench (pl. 7, fig. a). Near the north end of this trench the foot-wall lead has a dip of 60° S. South of the axis of the small synclinal sag, it appar-

ently rises slowly, for in one place slate lies horizontal; and at the axis of the anticline the lead comes up at an angle of 30°, over a thin stratum of whin which underlies the belt. At the trench this is narrow, and the lead is seen descending the south side at an average angle of 10° but "rolling" heavily. Near the south end of the trench the hanging wall lead has a dip of 5° S., but becomes steeper within a few feet. It is overlain by the same quartzite which is seen in the quarry to the west, and above this lies the Ferguson, a lead which at the south edge of the quarry occupies a similar position. A feature of these exposures is the easterly pitch of the beds, continued from the area west of the fault. The foot-wall lead plunges east 10°, and the hanging wall 5°, where seen.

The south trench gives an almost continuous series of dips. The greater steepness of the rocks, compared with observations farther east, has already been noted. The axis of the south anticline is determinable in this trench precisely. At a distance 152 feet south of the north end of the trench, a ledge appeared in 1899 to give both north and south dips. Although only two and one-half feet broad at the base, it had a dip of 50° N. on the north, and a steep south dip on the south side. Blasting revealed an arched lead, showing the exact position of the axis (pl. 11, fig. i).

Division iii: interpretation, and correlation with div. ii.— In interpretating the data in this block in terms of a structural section, two points must be emphasized. One is that in 300 feet north from the quarry on areas 73 and 74, there is but one exposure: the other relates to the interpretation of division ii. There, upon what appear to be safe and adequate grounds, a structure is worked out which makes the Taylor belt a horizon equivalent to the Copper belt, or strata very close to it. The former is found again in division iii; and if the interpretation is correct, the equivalence must be continued. This shows a change of shape to have taken place in the north anticline, and in the position of the subsidiary fold with reference to it (pl. 5).

The latter is low, instead of resting high on the bulging side of the former; and the main fold is therefore much steeper on its south side. The south anticline remains nearly the same as in the other two divisions, its axis here dipping 85° S. The syncline to the north of it apparently dips 80° S.

The subsidiary fold is better developed than in division ii. Its axes all dip 85° N. Since the bulge on the south side of the north anticline is hypothetical to some extent, having only one exposure for direct evidence, it is difficult to give its axial dip.. The structure is best explained, however, by an inclination of 70° N. for the axis of the syncline south of the bulge. Had the section been made near the eastern side of the block instead of the western, the south anticline would be found to have pitched down to a somewhat lower level, with reference to the others. The axial plane of the north anticline dips 85° S.

Division iv.—In many ways division iv is not so well known as the two to the west. The openings are fewer, shallower, and for the most part in disuse. At the critical portion, however, a large quarry has been opened, and two smaller ones to the east. North of the Little North there has been almost no prospecting. Between this and the North Sutherland the rock is largely slate, and south of the latter is practically all slate to the Miller lead.

Division iv: subsidiary and south anticlines.—The only dips north of the axis of the north anticline are the three leads given on the map, and considered by those who worked them in earlier years to be the equivalents of leads of the same name west of the fault. South from the axis are, or have been, a number of exposures with leads, now for the most part abandoned. All were cut very shallow, and information regarding them is hard to get. The new quarry on areas 76 and 77, lying along the middle anticline, gives the same structure as in corresponding parts of division iii; but the southernmost of the axes is farther from the center of the sag. The rock here is a black lustrous slate with a few green bands. To the south

it is noticeable that the south syncline is one of low dips on the whole, instead of the high dips prevailing to the west. The south anticline has dips much like those in similar situations to the west.

Division iv: axial dips and plunges.—The southern and subsidiary anticlines are still pitching east. The former plunges steeply immediately east of the fault, but flattens out after two hundred feet are passed. The latter pitches 15° E. in the large quarry, 6° in the cut at the north of area 78, and 10° in the square quarry to the south. Hence it too is rapidly flattening. The axis of the north anticline dips 85° S. The axes of the compound subsidiary fold have not changed their attitude. That of the syncline north of this fold dips 75° N., having steepened somewhat. The axes of the south anticline and syncline dip 78° S. and 82° S., respectively.

Division iv: correlation with division iii.—Despite the presence of the eastward plunge in the two southern anticlines, which should bring newer beds to the surface eastward, the only feasible interpretation of the structure, as represented by cross-section (pl. 6), gives older strata at the surface. This is on the basis (1) of the distribution of dips in the field, (2) of the approximate equivalence of the Copper horizon with the Jo. Taylor belt. There is so much change that on the subsidiary fold the Jo. Taylor belt would be 260 to 270 feet above the present surface.

The folds have not changed their character materially, but their relative positions are altered. The north anticline is still broad, and the local anticline is still close to the sharp south main fold. But the distribution of dips in the field places the north synclinal axis much nearer the north anticline, so that, although the dips on the south side of the syncline are low, the strata rise considerably upward. It is this that brings the horizon of the Copper lead, or its equivalent the Jo. Taylor belt, so far above the present surface at the crest of the south main anticline.

Summary of Moose River folding.—The theoretical considerations regarding these and other folds in the Meguma will be given in a subsequent paper on the structure of the series. It is sufficient here to recapitulate the conditions found in the field.

The simplest structure of this type is the elliptical dome, striking roughly east and west. The modifications in Moose River are such as to distinguish the region from all others :—(1) two main axes instead of one, giving two anticlines, both of great extent along the strike and prominent in the structure of the series ; (2) their convergence westward and final union within the limits of the district ; (3) the presence of a thick slate horizon, included in both folds and overlain by massive beds of quartzite, instead of the alternate whin and slate strata of other domes. This makes possible (4) the puckering up of part of this slate belt into an intermediate anticline, itself compound, and probably dying out east and west within a comparatively short distance ; (5) the plunging of the axes of the main folds, not at both ends as in an ideal case, but one eastward, the other westward ; and (6) the plunging of the intermediate fold eastward, or in the direction of divergence of the axes of the main anticlines. It probably broadens and flattens out until gradually lost ; yet there is some evidence that it, or another in its place, exists six miles east, near Otter lake, where the two main folds are half a mile apart.

The vertical thickness of sediments involved, between No. 7 on the north and the veins in the center of area 970 block 4, on the south, is only about 370 feet.

FAULTS.

Classes of movements.—The faults of the Meguma series fall for the most part into two large types—cross faults, cutting across the strike of the long folds at high angles, and often extending for miles ; and radial faults, striking outward on the plunging ends of domes. There are some that are outside

this classification, but it includes by far the larger number. Of the radial type Moose River has none. Of the other class it has several, three of some size. The evidence for these, and the character of the dislocations, are detailed below.

The direction of motion along the fault plane, and the position of each block with reference to the adjacent ones, are difficult problems because the data are not at first glance always consistent. The simple possibilities in any case may be grouped under four heads:— (1) vertical motion, the east side rising or falling with reference to the west; (2) horizontal motion, the east going north or south; (3) oblique sliding, the east going up or down and north or south. These are all motions of mere translation. There may have been (4) a shearing, upon a fulcrum within or without the field. More than one of these possibilities may be fulfilled in a single fault, and the whole may be complicated by compression of the strata, equalized or differential. These conditions must be examined for each fault in the light of the distribution of dips shown by strata, leads, and axes of folds.

West fault: course.—This fault has been visible in the west stope of the Big North lead, and obscurely at the west end of the quarry to the north. In tracing out the BigNorth lead it was lost at the break, and was thought to have been recovered on the west side, twelve feet south. I do not think, however, that it has been found, and this opinion is shared by most of those who have worked the lead. At this point, therefore, the horizontal displacement is an unknown distance, quite certainly not much beyond twelve feet. In the west stope of the Big North, the fracture dipped 85° E. Whether this is characteristic of the fault as a whole there are no data for discovering. From the Bruce belt, which was tunnelled west to the break, a cross-cut was driven fourteen feet south, beyond the fault, but without success. Hence the displacement here is at least that amount. From the fault as exposed in the Big North to the west end of the Bruce tunnel is S. 5° E. The position of

the fault at the south side of the field is inferred. The leads in the drain on area 32 all have high north dips, as far as seen by me, and correspond closely to leads in the trench on area 30. Directly east along the strike of the former, however, the leads dip south. Hence the fault must run east of the drain; and probably not far east, because of the considerable change in strike of the fault involved. Taking this into account, I have plotted this portion S. 8° E.

West fault: details of displacements.—The horizontal displacement at the north end of the section is believed to be small, because the Alex. Taylor has dips which would be expected in a lead at the distance south of the anticlinal axis here represented. Were this axis much nearer, the surface dips should be less. At the south end the positions of the synclinal and anticlinal axes in division ii are known with great exactness. That of the anticlinal axis in division i is known quite closely, by reason of the strata at the Touquoy crusher and the leads in the trench. From these data the horizontal displacement of the southernmost axis is calculated to be 50 feet. This gives a positive overlap of 10 feet, and offset of 47.5 feet to the left. These functions have not been computed for the northern anticline, because so small and so problematical.

West fault: direction of motion.—The determination of the direction of motion along the fracture receives little aid from the exposures in the open quarry on area 169 and the west stope of the Big North; for here the fault is a zone, the gouge of which is composed of pieces that have moved in various directions. Dips must be used as far as they give evidence.

(1) In a vertical motion of translation, if the east side rose, the axes of the main anticlines east of the fault would, upon denudation to the present level, migrate southward. Such evidently is not the case. If the east side fell, the axes would migrate southward on the west. On account of the obvious difference in inclination of these axes the northern one, having a lower dip, would migrate the farther, and the two axes would be

nearer together west of the break. The opposite condition obtains. Finally, if not aided by some other movement, a vertical one would leave the dips of the axes unchanged.

(2) A horizontal motion of translation, unaccompanied by any other change, would keep the axes equidistant on either side of the fault, and would not alter their dips. Here the axes on the east, according to the best data obtainable, are forty feet nearer together than on the west; and their dips are altered.

(3) An oblique motion of translation appears at first sight to meet the conditions. By calculation, if the axes east of the fault hold their dip, a movement of the east side up and north 118 feet at an angle of 60° from the horizontal would, upon erosion to a level, give the axes of division ii the position which they now occupy. But there are two other criteria. After an upthrow and subsequent denudation, any horizon is farther from the axis of an anticline than before. As no strata or leads in the two divisions have been proved identical, this test cannot be used. But, second, east of the break the dips of the axial planes are different from those to the west. Unless disturbed by some other movement, they should remain unchanged.

(4) A shearing might make the south end of division ii rise or fall with respect to division i, on a fulcrum within the zone of leads or north or south of it. Consider first the case of a fulcrum between No. 7 on the north and the Root Hog on the south. If the south side fell, the axes of the two anticlines would be brought nearer together; the north migrating south for a considerable distance because of its low dip, unless the fulcrum were near it, and the south axis lying a very short distance north or south of its present position, depending upon the position of the fulcrum. This obviously has not happened. If the south rose, the axes would be farther apart, and the north one would dip less than 60°, which is not true. Second, if the fulcrum were beyond the axis of the north anticline, and the south fell, a shearing of such sort as would place the north axis in division ii where it is and give it a dip of 70° S., would make

the south axis dip 85° N., instead of 82° S., and would not bring the two into their present distance relations. If the south rose, the axes would migrate south, and they did not. Similar objections hold, upon the supposition of a fulcrum south of the field. Thus it appears that no one of the possible classes of movements can account unaided for the present conditions; and a combination of two or more would fail as surely.

If, however, the effect is considered of a compression of the folds, acting in conjunction with the faulting, it is found that any one of the four methods is available. But only two are quantitatively probable :—(1) horizontal movement of the east block northward with reference to the other; and (2) an oblique motion on the east side up and northward, with compression from the south. It is at present impossible to state positively which of the two is correct, because we have not, as in comparing divisions ii and iii, definite horizons by which vertical change can be computed. If (2) be accepted, the proportion of oblique motion to compression is hard to determine, because the latter has altered the dip of the axial planes. In the case of (1), the amount of direct sliding of the whole mass depends upon the position in the north anticline of the fulcrum upon which that axis has turned from 60° to 70°. If this fulcrum lay at the present surface of the ground, the east mass as a whole moved north the whole distance of the offset of the north axis. If the fulcrum lay below the surface, the movement of the whole east block was greater than this; if above the surface, it was less, and may theoretically have been negative, or southward. In any of these cases, compression horizontally accounts for all the motion represented by the difference between the motion of translation and the offset of the south anticline.

But steepening the dip of an axis in the course of compression inevitably alters the dip of the strata, on one side adding to the increase of dip of the beds accomplished by the compression itself. The steepening will occur on the side of the fold towards which the axis dips; and will be least, perhaps almost nothing,

at the level of the fulcrum and near the axis, increasing outward and above and below it. Such evidence as we have indicates that the south dips of the north anticline were not steepened appreciably in the change from 60° to 70° axial dip; hence if (1) is to be accepted, the direct sliding must have been nearly the distance of the offset of the north axis, or about ten feet, the axis steepening 10° about a fulcrum placed close to the present surface of the ground. Of the southern part of the section, all that can be said is that in addition to the ten feet absolute movement north, there was a farther one caused by compression, less northward and greater southward, amounting at the southern axis to 37.5 feet at the most. This appears, of the two, the more plausible explanation. In the course of compression, the south anticlinal axis was decreased in dip from 85° S. to 82° S.

Middle fault: course and attitude.—The evidence as to the functions of this fault are far clearer than of the one just described. Its direction throughout its observed length is N. 19° E. At the north end it has been met in working the Copper and Little North on the west, and these and the Little South on the east. The last has not been opened west of the break because, such is the lack of system in the development of these districts, no cross-cut has ever been made for it. The workings on these leads were abandoned in 1897 or 1898, and I have seen the fault below ground but once. There it appeared as a zone of fractured material, with a breadth not measurable at the time, and dipping east at a very slight angle from the vertical. Indeed, experience seems to show that most of the north-south faults in this series, where their dip is measurable, incline east

Middle fault: displacements.—If the Copper and Little North had kept their strike eastward to this fault, their horizontal displacement would be 95 feet. But instead, they turn strongly northeast. In other parts of the district, some turn thus in the direction of motion, and some do not. The former cases are probably in the nature of a drag, except where the axis of the

fold plunges. In view of this, even though the turn extends westward for a considerable distance, it has been thought best to neglect it and to base the measurement of displacement upon the general strike. But the south end of division iii is not faulted at all, being merely dragged. Hence the axis of the north anticline is plotted as displaced 70 feet, an amount proportional to its distance from the south end of the faulted area. At the Copper lead, a total displacement of 95 feet gives a negative overlap of 20 feet, and an offset of 92.5 left. The north anticlinal axis has a negative overlap of 17.5 feet and an offset of 66.75 feet left.

At and near the eastern end of the quarry, area 71, the fault could be seen in three places in 1899. The most northern was a small pit nearly in the centre of area 71, where it dips 68° E. (pl. 9, fig b). The strata east of the fault are here nearly horizontal, for the more southerly of the two anticlines which form the large subsidiary one broadens and flattens westward. The second exposure of the fault was in a circular pit east of the large quarry, and topographically several feet lower than the first. Here it is essentially perpendicular. Its direction changes erratically in the fifteen feet of section, being at the south end of the pit N. 60° E., and at the north end E.-W. (pl. 11, fig. h). At the east end of the quarry itself, or rather in a short cave excavated eastward from it, the break is again visible. In the second pit just mentioned, the hanging wall lead of the Jo. Taylor belt comes up on the east at a high angle (pl. 9, fig. a). It is said to have been tunnelled east to the small fault on area 72, meeting underground workings east of that point. The total horizontal displacement at this point is 37.5 feet. The overlap and offset are difficult to measure, on account of the curved strike of the Taylor belt west of the fault. If this were due merely to drag, the problem would be simple ; but north of the local anticlinal axis west of the break th · strike is northwest, showing that the strata really plunge downward toward the east (pl. 18.)

Middle fault : southern limit of dislocation.—That the fault

extends south of the quarry admits of no doubt. But in tunnelling the Smith belt east, it was not met, although the works crossed the strike of the break. Instead of faulting to the north, the belt departs from the normal strike, turning northeast, as though dragged severely but not fractured. It appears, then, that the fault stops short of this belt, probably close to it on the north, and becomes at that horizon a very local cross fold.

Middle fault: essential unity of divisions ii and iii.—In deciding what is the character of the movement which division iii has suffered in its faulting, it will not be necessary to go so fully into the theoretical possibilities as in the preceding case. Divisions ii and iii are in some respects a single structural unit. They are the only ones showing the Jo. Taylor belt. Both were shoved north by the west fault, and the difference in attitude is the result merely of a rupture within the block, at one end not extending to the limit of the field.

Middle fault: direction and character of movement.—It is evident at once that a mere motion of translation, horizontal, vertical or oblique, will not account for the growth of the fault. It is equally evident, when tested quantitatively, that the only shearing possible under the conditions—the east side going up toward the north on a fulcrum at or few feet south of the south anticlinal axis—would violate two conditions found in the field. If the north end rose upon a fulcrum at the present outcropping of the Jo. Taylor belt, so as to leave the latter where it is found in division iii, the Copper lead might lie at its present position east of the fault, but probably would be farther north. This is upon the supposition that the axis of the north anticline has been tilted from a dip of 70° S. to 85° S., which has occurred But the axis of the south anticline would change its dip from 82° S. to 83° N., instead of 85° S., its present angle; and finally, the movement would not account for the changes in the character of the north anticline and the subsidiary folds south of it.

Again, owing to the downward convergence of the main anticlinal axes in division ii, a shearing of the north end upward

would bring these axes closer together after denudation to the present surface, whereas in this division they are farther apart than to the west. From the axis of the main syncline to that of the north anticline, the distances average nearly the same in both blocks. It is noticeable also that the distances between the two anticlinal axes in divisions iii and i are practically the same; and that the horizontal displacement of the south anticlinal axis at the west fault, added to the amount of flexing northward which it received south of the end of the middle fault, is equal to the total horizontal displacement of the north anticlinal axis by the latter fault.

Appeal must be made, then, to some other movement, influencing shearing, to account for the structure of this division. It seems clear that the force which produced the chief faulting of the district, first broke off as a single block all the rock between the west and east faults, shoving it north nearly fifty feet. In the western part of the block, resistence from the north compressed the folds to the extent of 37.5 feet. The eastern part of the block, not meeting with so much resistance, largely broke away from the western, along the line of the middle fault. This break began at the north end, and died out before it reached the axis of the southern anticline, because the rock of division ii took up the compression so that it was slightly felt so far south. There was, then, relatively no compression of this eastern portion, the block moving north as a whole. This explains the distance relations referred to above.

There was, however, a bulging upward of the northern half, due possibly to resistance on the north which was unable to compress the strata as in division ii. This bulge had its southern limit an undetermined but short distance north of the quarry on areas 73 and 74. Thence northward the dips steepened to the axis of the north anticline, which was tilted from 70° S. to 85° S. The north end of this bulge must have been a considerable distance beyond the field of the map, for the north anticline was not compressed to an appreciable degree. Moreover, the angle

between the average dip of the strata on the north and on the south sides of the axis is the same in divisions ii and iii. Thus there is little distortion of the anticline by differential movement.

East fault: course; aspect at east quarry.—The east fault runs N. 22° E. It is visible in the west end of the quarry on areas 76 and 77, nearly perpendicular, with a very slight inclination to the east. It is inconspicuous, as slate lies on both sides. The fracture is a narrow zone, occupied by soft gouge and bounded by well slickensided walls. The testimony of these slickensides is conflicting, because of the various directions in which solid masses in the gouge moved in different places, under the influence of the crushing and slipping strains. In the Comstock and Big South leads, the fault was met in earlier years underground.

East fault: displacements in southern part of field.—Beginning at the south end in division iii, the position of the axis of the south anticline is by continuation from a known point in the western part of the block. It probably is not dragged north by the east fault; for the south anticline is evidently pitching east in the eastern part of division iii, as shown by the converging dips on both sides of the axis, and the curve of the Comstock lead is sufficiently explained by this. East of the fault the axis has been displaced 192.5 feet north. Its position is closely defined by a lead lately uncovered, west of the large abandoned crusher; and one somewhat similarly situated south of the axis. Their convergence indicates the continued eastward plunge of the fold. The offset of this axis is 185 feet left, and its overlap 62.5 feet negative. This is the largest displacement in the district, and northward the distances become steadily less.

The position of the main synclinal axis is indicated very closely, the nearest exposures of opposite dip being only a few feet apart. North of the large quarry only two exposures of any kind are visible, till the North Sutherland is reached.

These both show low dips. The displacements of the north anticlinal and synclinal axes are plotted as intermediate between 192.5 feet on the south, and 110 on the north, the amount being reckoned with reference to the observations farthest north and south. This gives for the anticlinal axis a horizontal displacement of 142.5 feet, an offset of 127.5 left, and an overlap of 57.5 feet negative.

East fault: explanation of movements, and present attitude of division iv.—The structure of division iv cannot be explained by either horizontal or vertical sliding, or by shearing, unaided; for the present relations of the parts, compared with similar ones west of the fault, are not such as should be found after any of these classes of movements. The Little North is in division iv farther from the axis than in the cross-section drawn for division iii. If the axis continues parallel to the leads eastward to the fault, since the dip of the axis has not changed, it may be fair to consider that the difference in distance has resulted from a vertical movement. This could be made by a rise of 52.5 feet on the east, in this part of the block. But if such were the case, the axis east of the break would now be south of that part to the west, because of its migration down the dip. It is probable, in view especially of the divergence of strikes between the north of the district and the remainder, in divisions iii and iv, that the north anticlinal axis takes an intermediate course, as plotted. On this basis, the north leads are so situated in division iv with reference to the axis, as not to require an upward motion to explain their position. The alternative is a northward horizontal sliding of the whole block to the extent of 129.5 feet, the offset of the fault at the north axis; and a compression of the north side of the fold to an extent of 29.5, measured at the Little North.

The changed attitude of the southern part of the field in this block, relative to the northern anticline, is such that only a bulging upward could account for it. The northern limit of this movement was at the center of that fold. The action did not

turn back the north anticline, else it would have steepened the leads to the north, and lowered the dip of the axis. But the leads on the whole are lower than to the west. The southern limit of the bulge is probably not far south of the district. An upthrust of which the south anticline were the center would leave the axial dip unchanged. If this fold were not the center, the dip would be made higher or lower according as the fold were south or north of the center. The axial change is 3° to a lower dip. Hence the southern limit of the bulge should be sought south of the axis of the south anticline somewhat farther than the distance of that axis to the axis of the north anticline, which is 425 feet. There must also have been a compression of the southern part of the block, accounting for the increased displacement at that end. The amount recorded is 85 feet horizontally. But the vertical upthrust of 260 to 270 feet, on an axis dipping 85° N., would cause the south anticlinal axis to migrate 50 feet south when eroded to the present level. Hence the total transverse compression here amounts to 135 feet, becoming less northward. To produce this result there must have been a strong resistance on the north.

Minor faults.—In the underground workings, minute faults are constantly being found. These are in every conceivable attitude, some in the stratification, some in the cleavage, but most with strikes transverse to both. They are identifiable by slight displacements of known horizons and by slickensides. They exercise a compensating rather than a cumulative effect, and thus do not alter the structure of any portion of the district to an appreciable extent. Certain effects of slipping along cleavage will be considered later.

Of the smaller faults shown on the map, none are important. All are nearly or quite transverse, none radiating from the noses of plunging anticlines, and none striking parallel with the sediments. Many follow joint planes. The one on areas 173 and 174 is one which does not displace the beds horizontally, but at which

they turn from their former strike; and another on areas 126 and 175 is of the same kind. These were met in the old underground workings, and have not been visible during the progress of this study. On area 72 is a very local fault cutting the Jo. Taylor belt, and met in tunnelling in earlier years. On area 73, at the west end of the quarry, a fault with a horizontal displacement of scarcely four feet is visible. Here, as along most of the faults, the east side has gone north with reference to the west. On the south side of the quarry is a small break with a strike N. 73° E., and a dip 87° S. Slickensides show the south to have gone east horizontally. The whole is, like many others, too minute to plot on the map. It is the nearest to a strike fault of any in the district. At the northeast corner of the quarry a slight dislocation runs northwest. On area 75, at the west end of the quarry which occupies its center, slickensides show a slight perpendicular fault or series of parallel ones, running about northwest. The direction of motion cannot be made out. On area 177 a fault has cut off the leads which come from the west. The displacement is unknown, because no development work has been done immediately to the east; but it must be small. A fault of some length, which appears to die out at both ends, runs through areas 77, 124 and 123. It does not influence the south anticlinal axis. It is visible at the east end of the quarry on area 77, as a perpendicular slickensided fissure. The displacements of the axes of the local fold are reckoned from the distribution of dips in the immediate vicinity. On area 123 the flat-lying lead is cut off by a break which must, however, be very local. On areas 24 and 77 is a fault which has a displacement of four feet at the south end, and hardly so much at the north, where the Cowan lead is visibly dislocated by it. There are probably many more faults, covered by the drift, which more extensive development may bring to light.

JOINTS.

It is a marked characteristic of the district, and apparently of the series throughout, to have many local joints but no great

systems. Perhaps the most abundant run about north and south magnetic, but they are not persistent for more than a few yards. For the most part they neither aid nor retard open or underground development. One of the best joint planes forms the face of the westward spur in the east side of the quarry on area 74 (pl. 8, fig. a). No veining or mineralization has been seen along most of these fractures, except a few cases of pyrite incrustations of a crystalline nature.

METAMORPHISM.

Dynamic character.—No intrusives are exposed in or near Moose River, the nearest granite—the Tangier massif—lying some miles south ; and all the metamorphism in this field is of the dynamic type. In brief, it consists of the microscopic redistribution of material in both types of sediments, the alteration of shales into clay slates by cleavage, and of sandstones into quartzites, and later into arenaceous slates by cleavage ; and finally, further local change of slates of both kinds into schists. These alterations are not uniformly distributed geographically, even in the same stratum. This may have a very direct bearing upon the interpretation of the highly metomorphosed rocks at the western end of the province.

Secondary minerals.—The cement of the quartzites is partly secondary silica, partly calcite, with a small amount of iron oxide in rocks taken from near the surface. The larger part appears to be calcite. It is probable, from the appearance of the slides, that all the cement, as it is at present, is secondary. Biotite and muscovite are abundant in some slides ; and a part, perhaps most, of the mica is secondary. None of the quartz grains show a direct elongation in the direction of cleavage.

The clay slates do not normally show any of these minerals. On the other hand, chlorite is found to a much greater extent than in the quartzites. The color of the slates depends in part upon this, but yet more upon original conditions of deposition. The rocks have, abundantly distributed in the direction of cleav-

age, knots of some light colored mineral. This is either calcite, or quartz grains, or indeterminate masses looking like almost decomposed felspar.

Arsenopyrite is not found in slides of slate, to any extent, but is present in those cut from quartzites; and fails to show stretching. Pyrite is abundant in both rocks. Usually it is elongated with the cleavage; but in some cases the crystalline shape is unaltered, and in others it has a ramified margin and cellular interior, because of having crystallized in the massive form and adapted itself to its surroundings. This variety often encloses bits of biotite and chlorite. Most of the cellular nature, however, results from the presence of quartz grains.

Cleavage and schistosity.—All the sediments are heavily cleaved. The planes of fissility are parallel to the general strike of the rocks; and in highly inclined strata, or those in which original division planes are poorly marked, cleavage is readily mistaken for bedding. The quartzite is poorly cleaved as a rule; but near the surface, weathering has in many places brought out the incipient fissility so as to give a tolerably good sandstone slate. The pelite has taken the cleavage well; but no such perfection is reached as in roofing slate, for the necessary uniformity of texture is wanting. In places even the slates show little cleavage to the eye underground, but blasting brings out the greater weakness along these planes, and the circulation of shallow under-water has increased fissility near the surface to a high degree.

The cleavage is everywhere highly inclined, but often several degrees from vertical. In the quarry at the center of area 75, it strikes N. 80° W., and dips 79° to 80° S. On area 132, at the exposure from which the "fossils" were taken, the direction is N. 87° W., dip 52° S. At the west end of the quarry on area 131, where the Serpent lead was exposed in 1897, it lies N. 80° W., with a dip 67° S. North of the district half a mile to a mile, several observations show it to be nearly vertical.

Slickensides along cleavage planes are abundant, usually taking the form of a smooth deposit of chlorite. In some openings there is a distinct serration of the contact of horizontal or low-lying strata. Examination has shown it to be due in a few instances to crenulation of the laminæ, developed so far as to give strain-slip cleavage. But this is only in slate. Between slate and whin, as in the quarry on areas 73 and 74 (pl. 8, fig. a; and 11, fig. b), it is the result of slipping along ordinary cleavage planes which happen to be nearly or quite perpendicular to the stratification. In this quarry the quartzite does not show cleavage well, except at the east end. This applies especially to the stratum overlying the Jo. Taylor belt. In general through the zone occupied by the subsidiary anticline, the preponderance of pelite has allowed a good fissility to be developed.

In the quarry on areas 76 and 77, the same stratum appears in different places as a well cleaved slate and as a fine knotted schist. As a whole the cleavage in this district ignores the small crenulations of the slate. When, however, it comes down on top of a corrugation in a quartz vein encased in slate, it often curves, sometimes parting to one side and the other, because the slate yields readily while the quartz is brittle (pl. 8, fig. b, and 15). This curving was well shown in 1897 in the west end of the quarry on area 131, on a large scale.

In many specimens pyrite is seen lying in the cleavage planes, but quartz veins never. This pyrite is not crystalline or massive granular, however, but always stretched into a thin plate, or at least so far as much to distort the shape of the original crystal. This proves conclusively the later date of the cleavage than any of the sulphide concentrations. Indeed, cleavage and jointing were the last great dynamic changes in the sediments. Arsenopyrite has resisted stretching, for the most part.

In thin section the quartzites show little appearance of cleavage. The quartz grains not only are not elongated, but when

irregular in shape generally have their longer axes parallel with the stratification. This was noted in all the slides in which the latter was visible. The secondary minerals in these rocks do not appear to form distinct bands giving cleavage or schistosity; and altogether the quartzites are quite massive when viewed under the microscope.

But the slates are strongly cleaved, as well as slate laminæ in the whin. The fissility results chiefly from a rearrangement of the kaolin, so that it lies in the cleavage bands rather than in those of stratification. It is aided, but probably not formed, by secondary minerals. Those rocks which in the hand specimen appear most schistose, even the fine knotted schists mentioned above, have only a slightly larger amount of secondary material, the schistosity being due to a microscopical wavy cleavage that seems to be crenulated without much regard to the knots of quartz or other minerals. It is this crenulation which, in part at least, gives the lustrous and silky appearance to the schists. Pyrite never influences cleavage.

Glacial pressure affected that part of the cleavage lying near the surface in many places. The best example is along the trenches in areas 30 and 71. Here all the top of the rock is in places crushed into a mass of small cleavage plates, which were gradually worked into the glacial gravel by the onward motion of the ice. Where this breaking up was not so complete, an overturning of the cleavage from a south to a north dip has taken place, accompanied by a great increase in the fissility of the rock; due in part to the ice strain, and in part to a later water circulation.

RECENT WEATHERING.

The weathering of the sediments consists largely of changes in the sulphides. The pyrite and arsenopyrite alter, in some cases giving sulphates, and in others not. As a whole the rocks stain little by this process. In some places the angular cavities left by the crystals are quite abundant.

The fissility of both slates and quartzites becomes more marked, the cleavage laminæ separating with increasing ease, the slates turning a paler color, and the quartzites whitening much from the grayish green so common in the unaltered condition. Where pyrite lies in abundance along stratification planes, its weathering aids in separating the strata and causing the appearing of open spaces between them.

PART II.—VEINS.

COMPOSITION.

Constituents.—The gangue in the veins of Moose River is chiefly quartz, with some calcite. Most of the leads have shown only quartz, and the cross veins appear to have no other gangue. The Little North has much calcite, and a few others have large amounts erratically distributed ; but in no case does it form the main part of the lead. It is mixed with the quartz without apparent system, sometimes occupying the whole width of the vein, again next the country rock, often in the center ; or in a few instances interbanded with quartz in distinct layers. It is surprising to find its cleavage planes often curved, giving a resemblance to a light colored siderite. Tests, however, have shown it to be calcite. The curving is gentle, but in a few cases quite sharp monoclinal folds half an inch high have been found. It is evident from a study of the adjacent rock that the curving is a result of dynamic action subsequent to the formation of the veins.

Arrangement of minerals.—The quartz is rarely cellular or drusy. A few druses show very distinct crystal faces on the walls. The cellular portions of the gangue are especially white, or are rusted by decomposition of a sulphide. Normally, however, the gangue is dark and ribbony, and uniformly dense. The gold is associated with this type, on the whole, more than with the other.

The leads never show a distinct comb structure. When druses occur at all, they are in the interior of masses which are,

as a whole, nearly or quite homogeneous; and quartz crystals appear never to have been found in layers, each with its longest axis perpendicular to the vein walls. The ribbony type referred to is the most abundant, and is best seen where, as often happens, thin laminæ of slate are included in the gangue, lying parallel to the mains walls.

The data relative to the ores will be considered under a separate head.

DISTRIBUTION.

Stratified leads.—The veins of Moose River belong to two groups, as regards their relation to the country rock—stratified, called "leads" throughout the province, and "cross" or unstratified veins. Connected with the former are the "angulars" (sometimes contracted to "anglers"). The distribution of the leads and angulars is erratic, the only system being their confinement within a zone represented by the width of the mining district north and south. This is because the whole field is a unit of slate, inclosed on either side by the overlying thick quartzite. There is whin within this zone, but it is not so abundant or important as in most districts in the series.

The nearest approach to a system is the scarcity of leads of any size on the subsidiary anticline, below the Jo. Taylor belt. Instead, the slate is full of minute stratified veinlets and seams of pyrite and arsenopyrite. These are present more or less throughout the whole thickness of rocks exposed in the district, but are especially characteristic of this part.

It was early thought that the veins were more numerous on the margins of the field, especially at the north, and decreased in abundance toward the center; but recent developments show that this apparent distribution was due in part to the chance order of opening.

Erratic veins.—The erratic veins belong to no particular series or age. They are unsystematically distributed, cut the bedded leads at all angles, and cross each other. It may be remarked here that in no case do veins which belong distinctly

to this class show signs of having been folded or disturbed to any extent since deposition.

ATTITUDE.

In a large way, the leads are chiefly parallel with the stratification of the country rock, thus partaking of all the structural peculiarities of the sediments. They are folded with the latter, and have been affected by faults as they have. This has caused it to be possible, in interpreting the structure of the region, to use these veins where the slate and quartzite were for the most part hidden.

Relation to belts of strata.—In position, the leads may lie in or between slate strata, or at the contact of slate and whin. While in most districts the latter situation is the more common, here it is not so. At many horizons there is no quartzite for a wall, yet leads occur in the slate in well-defined belts. This being the case, it is surprising to find the proportion of veins that break across from one bed to another small—fully as small as in other gold districts in the series. Where such irregularity does occur, it is always within narrow limits, as from the hanging to foot-wall sides, or vice versa, in a single horizon of slate backed up by whin. Where no quartzite is present, the distance of cross fracture is no greater. In the unstratified section of such vein, the wall is usually slightly more irregular than that of a bedded lead. Frequently only part of a lead has thus broken across, the rest continuing conformable with the sediments. Such bifurcations have not, in this district, been especially rich in gold.

Angulars.—Closely related to these is the class of veins called "angulars" or "anglers". These are usually branches of the main stratified lead, cutting irregularly across all structures, and dying out at a greater or less distance from the parent mass. They occupy fissures in the form often of irregular rents, which are widest near the main vein and decrease in size away from it, and evidently originated from the stratified lead. The char-

acter of the gangue does not differ from that in the parent vein. In some instances, in a distinct belt there is no single lead that is strictly interstratified; and the whole belt is a series of intermeshing veins which run parallel to the strike of the country rock, but across the dip. Such are the Dreadnaught and Kaulback belts. In Moose River, angulars of this class have no great length on the strike, but in some other districts a belt of them occasionally reaches a length of 2000 feet. Where an angular of either type meets a main lead, pockets of ore are sometimes found. Spurs from the stratified leads never, so far as observed, break up vertically or across horizontally through several strata, but are virtually confined to a single belt, whether in slate alone or in slate between whin walls. They occur, however, indiscriminately on hanging and foot-wall sides of leads and belts.

The best example of a belt of angulars is the Kaulback belt, opened in 1901, and cut to the 170-foot level by August of that year. The leads here have the strike of the sediments—N. 85° E.—but there is no vein among those occupying the belt that is strictly conformable in dip for more than a few yards vertically.

Confinement to one side of a fold.—Although continuous along the strike, and generally in depth as far as worked, the leads of Moose River are, with two exceptions, not found on both sides of a fold. Local miners often express belief that a certain lead is the same as some other on the opposite side of an axis; but there is nothing to warrant this here except an occasional general similarity between the two. One of the exceptions is the case of the Great North (pl. 14) and the Serpent, which, when the west stope on areas 131 and 132 was open, could be seen turning from the north dip to the west and slightly to the south. Lack of exploration prevents knowledge as to how far it extends on the south. The second case is that of the Jo. Taylor belt, the hanging wall lead of which turns from a south to a north dip on the plunge in the quarry on area 71, and has also been excavated on the north dip at the east end of the quarry on areas 73 and 74. In the former, it is found only as

far north as the north side of the subsidiary syncline. In the latter, it extends to the north side of the subsidiary anticline, and appears to be pinching out at the north side of the quarry. None of the leads first worked, on the north dip of the north main anticline, have been found on the intermediate or south anticlines.

Crenulations: relation to stratification.—Two detailed features of the attitude of the veins are crinkling and "rolling". The former is very characteristic of this district, and is found in both stratified and cross veins. It consists in a corrugation of the whole width of the vein, coarse or fine according to the thickness of the latter, and in strict conformity with the bedding in the stratified ones. The lamination of the slates follows the crenulations of the lead, exactly when near it, less faithfully when farther away.

Crenulations : variation in size and shape.—The amplitude and interval of the curves vary greatly, apparently depending upon the size of the vein and the proportion of arenaceous material in the country rock adjacent. The west side of the quarry on area 76 shows this feature. Here, bounded only by slate, are very many stratified veinlets of quartz. In some there is a thinning of the vein from half an inch down to one-quarter or one-eight of an inch in thickness. Accompanying this is a gradual and proportionate diminution in the size of the corrugations made by the veins. A few inches above and below, the slate laminæ are undisturbed ; and all gradations are found between this state and that close to the quartz, in which the minutest crenulations of the latter are reproduced in the slate. Another case is shown in pl. 11, fig. a, in which the vein is half an inch thick on the south, decreasing to a mere film on the north, the crenulations becoming smaller also in that direction. A still better one was visible in 1901 at the 60-foot level of the Kaulback belt, in the north tunnel, where the strata dip 60° S. The vein in question is one of the belt of angulars, and at this point cuts across the bedding for a few feet, then turns upward

parallel to it. It dies out completely before reaching the surface. The laminæ of slate close to the lead curve with it, but the general stratification is unchanged (pl. 11, fig. c).

In shape, the crinkling varies from broad open folds to close and overturned ones. The latter, in inclined strata, are overturned uphill, as in pl. 13. The curves may or may not be rhythmic. When even in interval they usually are uniform in amplitude. When uneven in either way, there often is some system in their irregularity, a rhythmic change such as in pl. 11, figs. e, f, being common. In a larger way most of the leads show the same thing. Thus the Jo. Taylor, especially the footwall lead in the quarry on areas 73 and 74, is corrugated evenly and steadily for many feet across the strike. Those show it best, perhaps, that lie in belts bounded on one or both sides by whin. Here the veins are crenulated strongly, the size of the folds being still proportional to the breadth of quartz. The sharpness of curvature is inversely as the thickness of the veins. In these cases the slate is folded to a thickness depending upon the size of the vein and violence of its contortion, and the proximity of whin. Sympathetic folding of the country rock rarely extends more than two feet away from the lead, on either side. If whin bounds the belt within the distance to which this folding would tend to extend, the latter is arrested, never affecting the whin. When, as often happens, the lead lies along one wall of the belt, the adjacent whin prevents rolling of the strata on that side. It is never strictly true, however, that the vein lies next the wall. A thin band or rind of slate intervenes, and is frequently closely folded, slickensided and crushed by the intense strains to which it has been subjected. This is not especially well shown at Moose River, because whin walls are rare.

Crenulations: Kaulback belt of angulars.—A special case is found in that class of angulars which run parallel to the strike of the strata, but break across the dip. Some belts are composed entirely of a network of such veins, instead of having bedded leads. In these instances the belt as a whole follows the

stratification, while no one member of it does. In the best parts of the Kaulback belt, several veins run parallel to the bedding for a short distance, then oblique to the dip, then parallel again, and so on. The stringer described earlier as a thinning stratified vein, is part of this system (pl. 11, fig. c). Its upper edge stops 60 feet below the surface where cut in the north tunnel; and this terminus is lower and lower as one goes west, the line of limit having a plunge of 40° W. There are probably many such blind veins.

Six feet below the top of the drift in the level mentioned above, this vein cuts across the strata, and continues this relation from there down, receding from the axis of the anticline on the side of which the strata lie, more rapidly in depth than do the sediments. That is, the dip measured over a considerable section is less than that of the strata. With all its cross-cutting the vein retains its corrugation. On the whole the waves may be slightly larger where not parallel to the bedding. This may be due to the fact that in these portions the vein is considerably thicker than when conformable. In such places it breaks up into several stringers, which reunite later (pl. 12, figs. b, d). This occurs at the south tunnel in the 60-foot level, in a section in which bedding and cleavage are clearly shown. It is noticeable everywhere that veins do not as a rule break upward into overlying beds, but rather break upward into underlying strata, as in pl. 12, figs. a, c. The exceptions are angulars starting definitely upward from a bedded lead.

Crenulations: effects upon secondary structures. — Both joints and cleavage are turned out of their course by the sharp curving of resistant quartz veins, where the structures reach the crest of a fold. Joints are but broadly curved, cleavage sharply; and some of the planes of fissility are deflected past one side of the obstructing corrugation, some past the other, making a curved divergence of the fractures (pls. 8, fig. b, and 14, 15, 16).

Crenulations: cross veins.—Cross veins are in some cases corrugated, but not so frequently as the stratified leads. These curves have no relation to folds in the country rock, except in angulars parallel to the strike but not the dip of the sediments. They are more likely to be uneven in size and irregular in amplitude and interval; and rarely become progressively smaller with a thinning of the vein (pl. 11, fig. d). They are exposed particularly well in the new openings of the Kaulback belt, in the quarry on areas 73 and 74, and in that on areas 76 and 77.

Where the veins have a strike perpendicular or parallel to that of the cleavage, it might be expected that slipping along those planes, or the corrugation of the sediments close enough to give strain-slip cleavage, would account for the phenomenon. Instances of veins parallel with the strike of the cleavage (which is close to that of the strata except where folds plunge), but cutting the sediments in their dip, are confined to certain angulars. Those veins which run perpendicular to the strike of the cleavage must have two accompanying features, to be explicable by the method just mentioned. If they have slipped along ordinary cleavage planes, the strata enclosing them must also have slipped; but I have never found this to be the case, where such veins have been visible. Furthermore, where the strata are serrated, the serrations are small as compared with the corrugations in veins, and fairly uniform, with no irregularity comparable to that shown by the cross veins. If strain-slip cleavage caused the corrugations, we should find some sign of it also in the sediments, either cleavage or acute small-scale folding; but do not. The best cases in the veins occur where there are no corrugations in the strata, and where the major planes of division between the beds, which must be made uneven if slipping has taken place along any cleavage, are perfectly even in their dip. There is not the slightest deviation in the dip of the laminæ in proximity to the veins.

The more numerous instances of veins oblique to the strike of cleavage and stratification cannot be explained by any theory

of slipping or corrugation of the sediments; because either would produce structures diagonal to the vein, giving corrugations which would not be persistent in the vein for more than a few inches or feet, and which would appear to start on one side of the vein, pass through it obliquely, and come out on the opposite side at a distance along the strike of the vein. This has never been observed. The only explanation remaining, therefore, is that the cross veins lie in fissures which had their present sinuous course at the beginning of occupancy by the vein material. It is noticeable that this crenulation is not found in quartzite, unmixed with slate; but is confined to slate and alternations of the two. It is best developed where no quartzite is present. It appears, then, that in the thinly laminated pelites, at the time of intrusion of the cross veins, the rock broke under strain most easily across the strata squarely or diagonally in places, with the bedding in others, and in some backward or downward rather than upward.

Rolls.—In the stratified leads, most of the corrugations run horizontally or with a low dip. Where the anticlines plunge downward, however, these corrugations, instead of following the strike of the strata horizontally around the nose, take a course intermediate between the dip and strike of the rocks. Thus they may converge on the two sides of the nose of the fold and in the direction of its plunge, but not so sharply as the strike lines; and they dip, but not so steeply as the strata, nor in divergent directions like them. To such corrugations the term "roll" is applicable. It should be restricted to this phase, but is loosely used for large crenulations of any kind in leads. The true rolls are not well shown at Moose River, perhaps because of the scarcity of well-defined rock belts.

Pinching and swelling, so often mistaken for rolling, are not common at Moose River. Indeed, they are less abundant in this series as a whole than in other countries; and never due, as often there, to the sliding of one side of a sinuous vein upon the other, or to the chemical enlargement of the vein by solution of its walls.

Details of contacts.—It is chiefly in connection with corrugations that we often find the leads very laminated, the layers consisting of alternate bands of slate and quartz. Usually the layers of the latter are thick, of the former thin; but occasionally the reverse is true. The quartz in these laminæ is never cellular, and is generally dark and translucent. It is noticeable that the crenulation and rolling are accompanied by many fractures, upward from the crests and downward from the troughs; and that very rarely are these occupied by gangue, or by pyrite.

In close detail, the margins of the leads are seen not to follow the stratification, either in portions that are straight or in rolls. Some of these contacts are shown in photograph on pl. 14. Frequently in detail the vein breaks up into two or more stringers, or dies out and is replaced by another *en echelon*. In many specimens laminæ of slate are seen, wholly or partially detached, and thinning out rapidly to an edge. Several of these slivers may lie in close proximity in the lead. On the outside of the curve of rolls and other corrugations, the country rock gapes more or less, and into these fissures the vein material has penetrated; but this occurs also where the stratification is not curved.

In the slides all these features, and indeed several more, are shown in a very minute way, proving that in the finest detail the contacts have the same characters as on a larger scale.

RATIO OF VEIN MATERIAL TO SEDIMENTS.

In most fields and most parts of this field, isolated outcrops give a minimum amount of vein material in sight, across the strike of the folds. In the central belt here, in which the three trenches and large quarry were cut in or near 1899, continuous exposures give a maximum of quartz, under exceptionally favorable conditions for the formation of veins. In this zone, south of the north anticlinal axis, I have counted and measured 70 leads, in a distance of 750 feet, aggregating 300 inches in breadth of vein material. This gives 1 to 30 in cross-section—an extremely small amount. Yet this is higher than any

estimate I have been able to make elsewhere, and it is probably fair to consider it as near a maximum for any considerable breadth of rock. It is perhaps exceeded by two or three cases near the Isaac's Harbour district.

It is interesting to note, also, that in a portion where slate appears at first sight to be the only sediment, a large amount of arenaceous material is present. In the north trench it amounts to 33%, in the second trench to about 45%, and in the quarry on areas 71 and 72, where the slate is unusually abundant and clear, to 15%, in cross-section.

PART III. METALLIC CONTENTS OF THE ROCKS.

PYRITE

Relation to stratification planes.—Pyrite is the most important sulphide, and the most abundant. In connection with it and the arsenopyrite much of the gold occurs, in large part intimately associated. The pyrite is here chiefly in small cubes and granules, rarely in clusters of crystals or large granular masses. In the veins, however, granular accumulations are not uncommon. Reference has already been made to the presence of pyrite along the major planes of division of the strata. This is its most characteristic attitude in slates, or between slate and whin, even when much folded. These major planes of separation mark the greater changes in conditions of sedimentation, resulting in greater textural alternations; and the contiguous strata have comparatively little cohesion. Hence, with the rusting of the pyrites, fracture is easy along them. The minor planes divide strata of greater similarity and cohesion. Within quartzite, or between adjacent beds of it, the distribution of the mineral is irregular for the most part, and the crystals lie in all attitudes. Occasionally they occupy stratification planes in the whin; but rarely, for the rock is dense and homogeneous.

In the slate, the sulphide lies irregularly in the stratum, or more often is found along minor or major planes of separation.

It is most abundant in the last named situation, belonging very evidently to the upper of the two layers, and becoming gradually less abundant upward. Often at the top and immediately below the division plane, crystals are en irely absent. This is well shown in the quarry on areas 73 and 74, especially along the south side. In the small quarry on area 75, some of the strata have the greatest accumulation of pyrite along a medial plane, decreasing upward and somewhat less downward, with still a layer between the beds. The grouping of pyrite along the stratification planes is so constant in the slate, that in many other parts of the country, where layers are too similar to give the usual criteria of color and texture, and where bedding is obscured by strong cleavage, it has been possible to use planes of pyrite crystals with complete success in interpreting structure.

Attitude in leads and cross veins.—In the veins the mineral is abundant but often erratic in distribution, in places protruding into the quartz from the sediments. Within the vein it is irregular, and never occupies a definite central position. Its most important place, and commonest, is on the margins of the veins in sheets. While these are found on both sides, they are much more abundant on the hanging walls. This is brought out well in the zone of oxidation, by the rusting of the iron; below it is as real, but less apparent. The hanging wall lead of the Jo. Taylor belt, on areas 73 and 74, shows this. The rule does not hold in the irregular cross veins.

ARSENOPYRITE.

This occurs sparingly in the slate, abundantly in the whin, and in the veins is erratic in distribution but present in spots in considerable quantities. In the two first mentioned it is crystalized; in the last, massive except in a few instances. Very rarely a short vein is found composed entirely of a mixture of pyrite and arsenopyrite, but in Moose River these are of small size. In the sediments it is so rare in the slates as to be unimportant. Where present it is either in the stratum, or in a few

instances along the margin. In numerous cases a crystal has been seen lying directly across the plane of separation, partly in the upper and partly in the lower layer. In the quartzite its distribution is without system. The mineral is here always crystalline; and its striated prisms, up to half an inch in length, lie at all angels to the stratification planes, usually without arrangement. In a few places the crystals line the parting planes sparingly, but in general their position has no reference to them. In one or two cases the longest axis of the crystal crosses one of the major planes of division.

The distribution of arsenopyrite appears to have no relation to the proximity of veins, except in a few instances. The vicinity of the Britannia belt is thickly studded with coarse crystals, largely within the belt, and to a decreasing extent outward from it on either side. The veins themselves contain pyrite and arsenopyrite in massive and granular lumps, and the latter mineral somewhat crystallized locally. The gold in this belt is very pockety; and appears to have no present relation to the proximity of the sulphides, which by assay are shown to contain almost none of the metal. The habit of this belt is so peculiar as to give local miners the idea that it could be identified to the east, with one or more faults intervening. Thus in the south entrance to the quarry on area 73, the large lead in the south of the trench was thought by some to be the main Britannia, partly from expectation, partly because of the large amount of arsenopyrite near it. In this case, however, the lead itself contains none, and practically none is found on the south; while to the north the mineral extends throughout the length of the trench. At the east end of the district the Cowan lead has been called the Britannia, because of the accumulations of crystalline arsenopyrite. There is no probability that either of these represents the real Britannia.

The unsystematic arrangement, difference in crystallization in veins and country rock, and apparent lack of connection with the pyrite for the most part, are the most important character-

istics of this sulphide. It has already been mentioned that this mineral is never distorted by cleavage, while pyrite often is. Also, the former never occurs on cleavage and slickenside planes, while the latter frequently does.

MINOR SULPHIDES.

Pyrrhotite has been found very sparingly in the slate, but there is too little of it to assign it a definite distribution. Galena occurs in the bedded leads, and has been reported from slate in immediate proximity in two cases. It is uncommon. Where present it occupies the interior of the lead, in both quartz and calcite, and is never more than an eighth of an inch broad in single masses. It does not appear to influence the distribution of gold. Chalcopyrite has been found in irregular masses in both veins and sediments. In the latter, in several instances it has been stretched along the cleavage planes into thin plates, or else was deposited originally in that attitude. The former is more probable, in view of the polished surfaces of these thin sheets. I have never seen it in joint or fault planes.

GOLD.

In sediments.—Gold occurs in both sediments and veins. In the former it is held most in the slates, and often as much is found at a distance from the veins as near them ; but it is not uniform in distribution, as shown by a large number of assays made in 1899. The quartzite is not barren as a whole, however, although it carries on the average much less than the slate. A sufficient number of tests has never been made to prove any distinct relation between the run of gold in the whin and the proximity of leads. All the assays for this district were taken within the general slate zone. It has not yet been determined that the great mass of whin to the north carries any gold. In the sediments as a whole, little of the metal is free. Almost all is locked up in sulphides, even near the surface.

In veins: special enrichment.—In the veins, however, a large proportion is free within the zone of oxidation, and a small

amount below it, the percentage decreasing for some depth. In the free state it takes the form of filaments or wires, leaves and nuggety masses, small or large, and may be so fine as to be entirely invisible. In some cases the free gold is accompanied by sulphides, in others not. The larger masses are found usually, but not always, in "pockets" or local spots of enrichment. These are in some veins situated at or near the junction of angulars, particularly from the hanging wall, and the bedded leads. In other cases the metal is closely related to the presence of rolls, lying most often in the swell on the hanging wall. A considerable extent, either a whole vein or parts of several, may be characterized by the presence of these enriched spots, the spaces between being wholly or comparatively barren. In this district such accumulations are too discontinuous to form pay streaks, and distinct ore chutes are not so common here as on the more perfect domes. Wherever they do exist, they follow the dip of rolls. The Copper lead has one, with a very low west dip, in division ii. The Little North has two, perhaps three, with the same dip. These leads plunge west, and their rolls dip west, the ore chimneys following these closely. The Big North has one streak, on the west plunge, which was followed west to the west fault and lost.

Relations to vein walls.—In some belts the gold is so finely disseminated as to be invisible. Such concentrations as can be seen, yet not sufficiently high to call pockets, are often found in sheets of irregular thickness, lining the vein wall and projecting thence into the gangue. Rarely they tongue into the country rock. More often the sheets are smooth on that side, their irregularity being entirely toward the gangue. Where the gold lines the sides of rolls, it usually is bounded outwardly by a rusted zone when near the surface. From this lining wiry stringers, irregular masses and leaves project into the vein, often along distinct fractures.

Britannia and Kaulback belts.—These are two of the most instructive belts for the study of visible gold. In the former,

the only large accumulations were a series of pockets on a roll in the main vein. Here the metal occurred chiefly close to the hanging wall, running thence into the quartz. In this it lay as interlacing stringers, leafy expansions, and knotty bunches. Leaves were rare. In places the quartz was so intersected by wires that it could not readily be separated from the gold without fine crushing.

The Kaulback belt is composed entirely of angulars; but these are in the main parallel to the strike of the sediments, and are interstratified in parts. Evidently their origin is the same as the bedded leads. As a belt they follow the sediments; as individuals they do this only occasionally. In these veins the gold is more often on the margin than elsewhere, but in some places is abundant in the center. Certain characteristic appearances are reproduced in pl. 17, figs. c, d, e, f, g. Figs. c and d are typical of many cases, the gold lining the side of the vein, extremely smooth toward the country rock, rarely standing out into the slate, but serrated irregularly by projections on the vein side. These projections are usually small stringers, but occasionally too thick and obtuse to bear that name. The main part of the leaf is so thin that it can readily be peeled off from the quartz. These two figures are from a small mammillary bulge on the side of the vein. Such bulges are abundant. A little pyrite and arsenopyrite were in the quartz, but the gold appeared to bear no definite relation to them. In some instances, as in fig. g, the gold leaves the vein margin entirely, and runs some distance into the slate.

The gold of this belt is often closely associated with a steel colored mineral, which may be slightly altered arsenopyrite but does not have all of its superficial characters. The surface of the gold leaves is pitted with it, and it usually has a vesicular character itself. Inability to take away any of the specimens in which it was seen has made positive identification impossible. Both pyrite and arsenopyrite are abundant in the veins of this belt, in crystalline as well as massive form. This applies par-

ticularly to the latter mineral. Where bunches of these sulphides lie within the quartz, the gold sometimes occupies the margins and strings into the interior, sometimes is in leaves in the interior. In this case it always has connection with the margin. It is never seen against the side of a crystal of either sulphide. Both pyrite and arsenopyrite have drusy cavities when massive, but these are unoccupied, and give no evidence of having ever been filled.

PART IV.—SUMMARY OF GEOLOGICAL HISTORY.

The theoretical problems regarding structure of the rocks, origin of the veins and the ores, metamorphism, and other phenomena of the Meguma series as a whole, are being considered in separate papers, and will not be touched upon here. Certain events, such as the intrusion of the granites, have left no effect in this district, and their study must of necessity be pursued elsewhere. All that is intended in these paragraphs is an outline statement, without elaboration or defence, of certain important events in the history of the series, evidence for which can be obtained in Moose River.

The sediments were deposited in comparatively shallow water, in which currents distributed the detritus irregularly, giving a marked discontinuity of strata. In this way, here and there over the sea bottom and at different times, larger amounts of pelite were formed; either alternating with sands regularly, or more rarely having little sand dropped with the mud. Moose River represents the latter type of what elsewhere in this series of papers is called a "horizon of more abundant slate." Between these, geographically and stratigraphically, little but sand of various textures was laid down. Thus such a dome as Moose River has very definite limits, not only north and south by the overlying whin, but east and west; and its veins cannot be expected to extend indefinitely in any direction, nor to reappear on any other dome. The slate and vein-bearing horizons are also definitely limited in depth as well as in extent.

The accumulation was on a sinking sea bottom, in a syncline of deposition. The sediments at Moose River were among the first of which we have knowledge, but evidently not actually lowest in the series. The water may have contained lowly organized life in some form, as shown by the slight amounts of graphitic material in the rocks.

With the great accumulation of strata came gradual lithification, from pressure of overlying rocks and rise of the isogeothermal planes induced by the continual blanketing. It allowed considerable secondary alteration of the shales and sandstones, through increase in the solvency of the water of sedimentation, and showing itself especially in the deposition of secondary minerals.

Increased lateral pressure of necessity accompanied increased sinking of the sea bottom. There ensued more chemical action, and the beginning of the east and west folding. Simultaneously came the earliest deposition of vein material, along planes of weakness, which were stratification planes. At last the folds became marked in height, and greatest where plastic shale strata were abundant; and in the interstices between layers, and occasional radial gashes upward from the folds, the veins and ore had been gradually deposited, the latter in part remaining in the adjacent country rock.

Later, the greater rigidity of the rocks under pressure allowed jointing and faulting. Pressure kept the fracture planes tightly closed for the most part. Cleavage had been begun earlier, in an incipent way; but it had not developed into a mechanical fissility until all the vein concentration had ceased.

Denudation had been active on overlying beds, and finally reached the horizon of Moose River. Evidence elsewhere shows that by far the larger part of the denudation, which was the last great event in the history, took place before the close of lower Carboniferous times.

Appendix. Detailed Description of Leads.

In the following description of the gold-bearing leads, the data are given by divisions, as in the discussion of folds above. The statements are not intended to be complete; for, in a district mined in so desultory and fragmentary a manner as this has been, it is impossible to get reliable data in sufficient quantity regarding leads long idle. No mention of value is given; and, indeed, all statements of a pecuniary nature have been rigidly excluded from the paper. The information has been gained from every available source that is reliable—personal observation, Mr. Faribault's excellent map, and miners who have worked the leads in question in former years. The use of pl. 2 will be necessary throughout the description.

Division i.—This territory is much less opened up than that to the east. The Alex. Taylor lead is three inches thick where seen. At the north end of area 67 are two leads on the surface, which have never been opened; the northern five, the southern two inches wide. The Britannia is a belt of two leads, with a foot-wall of whin and no distinct hanging wall. The larger of these veins is six inches wide west of the river, and very white, and five inches thick in the main opening. The smaller lead averages four inches. Both roll heavily.

The Kaulback belt consists chiefly of two veins at the surface, two feet apart and stratified. At a depth of twelve to fifteen feet they break gently southward across the bedding, diverging somewhat, so that at 170 feet down on the slope they are five to six feet apart. They also turn slightly northwestward across the strike of the country rock. At various points they break up into stringers, sometimes reuniting again. South from the more southerly of the two leads 23 feet, at the 170-foot level, is a six-inch bedded lead, rolling strongly.

The vertical lead under the south corner of the Touquoy crusher is very uneven in thickness, running from a few inches up to nearly two and a half feet. Southeast of it, on the west

side of area 33, is a four-inch lead. Farther south a lead of three inches has a shaft over it, and within a few feet comes the South lead, of two inches.

There is little doubt but that many times this number of leads outcrop on the surface of the bedrock. All the trenches in this and other divisions, tend to emphasize this probability. On the west side of area 69 a cut 55.3 feet long was opened in 1899, in a search for the Britannia belt. It has since caved in. The first five feet from the south end is in slate, with a steep but undeterminable south dip. From five to twelve feet the rock is occupied by a belt of angulars. At the latter station is a two-inch lead. At 21.5 feet and 23.5 feet is a belt occupied by two very small leads; at 39 feet is the north side of a whin belt, and three feet farther is a narrow lead. At 52 feet is a lead of three to four inches thickness, and at 55 feet a small vein heavily corrugated. The Kaulback belt of angulars has already been described. It is difficult to estimate the thickness of quartz represented, on account of the many bifurcations of the veins. On area 32, in a drain which begins at the north end of the area, a number of leads were visible in 1899 after cleaning the excavation, and more were seen in earlier years. South from the north end 54 and 56 feet, the first leads are two which are thought to be the Moleskin belt, from similiarity in the appearance and relations of the quartz. No. 1 is one-fourth inch, and No. 2 is two inches thick. The third lead is 78 feet from the north end, six inches broad; the fourth 83 feet, 8.5 inches broad; the fifth 87 feet, four inches across; the sixth 90 feet south, two inches thick; and the seventh is 9 feet south of the area line, and 1.5 to 2 inches thick. They all have steep north dips.

Division ii: north anticline.—Beginning at the north of this division is No. 7, six to eight and sometimes ten inches thick, rolling heavily westward. The rock is largely quartzite to the Copper (pl. 13), which has two leads, three and four inches on the average. A slate belt of several feet was available also,

for crushing. There are said to be three leads between the Copper and No. 7; but I have never seen them, as they were met only in an old cross-cut, long since abandoned. Somewhat more slate is found in the country rock to the Little North. This again is really a belt of two leads, with two feet between them, in which some whin occurs with the slate. Altogether there are about four inches of quartz, rolling west at a very low dip. Some little whin is to be found between the Little North and Big North; but the rock is chiefly slate, with many veinlets of quartz interstratified. The Big North (pl. 14) is in a belt, with a whin hanging wall. The main lead lies on this wall, and averages four inches thick; is very curly, and has west-dipping rolls. The Serpent is perhaps the most irregular lead in the district, in places as low as two inches or somewhat less, in others as high as eighteen. It is extremely well corrugated, but unevenly, the thickest parts giving the largest and roundest curves (pls. 15, 16). It is remarkable for the clearness with which the relation between the crenulation, cleavage and jointing are shown in the sediments. This lead, better than any other, brings out the manner of breaking of the vein parallel with the laminæ of the slate.

Division ii: comparison with "West Mine."—It may be well to turn aside here, although not in the geographical order of treatment, to describe the leads at West Mine; for they are stated by their prospectors to be equivalent, in part at least to leads just described in the main settlement. At the head of the north trench (pl. 1, fig. b) is a four-inch lead. In the fourteen-foot belt a few feet south of it is a ten-inch vein on the foot-wall, and many stringers north of it through the slate to the limit of the belt. This is thought to be No. 7. The lead in the east-west trench, with a steep rolling north dip, is regarded as the Copper. The shaft south of this cut is over the Little North belt, eight feet wide with three leads—one on each wall and one in the belt. Southeast of this shaft is the vein thought to be the Big North. Here is a six-foot belt with a

three-inch lead on the foot-wall, and a small one on the hanging wall. Both roll heavily, as do also the rather rough walls, the foot-wall rolling ten inches deep.

Comparing these, lead for lead, with those described from farther east, we have little ground for belief in their identity. The northern ones have about the right intervals between each other, and are at equivalent distances from the probable position of the anticlinal axis. But the distance from the Little North to the Big North is far out of proportion. There is also a dissimilarity of belts, most marked in the two just mentioned. Altogether, I see no ground for classing them as identical with the eastern veins. The distance between the localities is greater than these leads are ever carried by direct observation. More than this, no lead or group of leads has ever been proved to descend the nose of a plunging fold and rise to the surface farther along the strike; and the most plausible theories of the origin of such veins render it improbable that they would do this. Finally, the rocks at West Mine are pitching west, as in the main district; and no proof has been found as yet, of an eastward plunge between the two places. Unless one exists, the former strata are structurally higher than the latter, and not their equivalents.

Division ii: subsidiary anticline.—Returning to division ii once more, no leads are found south of the Serpent and north of the Bruce belt, except a few filaments at the center of the anticline in the quarry on area 131, most of which do not outcrop at the surface. The Archibald vein I have no personal knowledge about, as its openings have been full of water for a number of years. The Bruce belt consists of several thin leads, occupying about a foot in width. In the quarry, no leads are met north of the Jo. Taylor belt (pl. 18) which was in early years tunnelled under the western two-thirds of the quarry. The belt is seven to eight feet thick, overlain by four feet of whin, and contains six leads. The hanging wall lead is exposed here better than farther east, the foot-wall one not so well. The corrugations of

the hanging wall lead are chiefly on the east plunge, and are continued east of the fault. The foot-wall lead is not crenulated here so much as in the quarry on areas 73 and 74. The total breadth of quartz in the belt is eight to ten inches.

Above the whin stratum mentioned lies the Ferguson, three inches thick, dipping 60° S. From this a shallow trench was cut in 1899 in the south entrance to the quarry, to expose any leads present. Five feet south of the Ferguson it brought to light a strongly corrugated lead, one and one-half inches thick, pinching perceptibly eastward. Six and a half feet from the first lead is another, one-quarter inch thick. At seven and one-half feet lies a half-inch vein, which may be an angular; at nine and one-half a one-inch corrugated lead; at ten and one-half a three-inch one; and at eleven a lead one and one-quarter inches thick, with some stringers on its hanging wall. The last four are all rolled closely together and in sympathy. At sixteen feet is a one-inch lead which rolls so heavily as to reverse its normal south dip in places. At 21 feet lies a quarter-inch lead, and at 25.5 feet a three-quarter-inch one. At 32 feet from the Ferguson is a large lead, six to twelve inches thick, with a strike N. 87° W. and a surface dip of 63° S., becoming somewhat less downward; and claimed by some to be the Britannia. It is very white, and lies in black graphitic slate; but has little or none of the arsenopyrite characteristic of that lead farther west. The slate for 30 feet north, however, has much of it in crystalline form. On the southeast side of this entrance to the quarry are several thin leads. East of the trench, on the excavated bank, is a narrow one, striking N. 87° W. and dipping 60° S. Probably it is identical with the one in the trench next south of the proposed Britannia.

Division ii: south anticline.—Three leads lie immediately south of the synclinal axis. In a hole at the north end of area 31 is the Bigelow, sometimes called the Big White, sixteen to 24 inches thick; and two and a half feet south of it a nine-inch lead, both very dense and white. Their attitude is nearly or

quite perpendicular. The Smith belt contains two leads, and an angular on the foot-wall of the northernmost, in the shaft. This is the belt which, when worked east, was found to curve around the south end of the middle fault. A few feet south lies the South Flat lead, five inches thick, parallel with the Smith. It has been exposed for several yards in a shallow cut, and curves on the strike, parallel to the former. Its eastern exposure, where it was possible to get the dip accurately in 1899, is really in division iii.

Division iii: north anticline.—On the east side of this fault block, a few feet north of the Copper, is a four-inch lead which does not, however, appear to be equivalent to No. 7. The Copper still has two leads, giving a foot of crushing material, including the slate which bounds it. The Little North has two feet of crushing material in the west, and one foot in the eastern half of the block. The Little South is a thin curly lead, with soft slate adjacent to it, giving a foot of good crushing rock. The Big North does not roll so much as at the west plunge, and averages about eight inches in thickness. At the east end of the block it is called the North Sutherland, although there is no reason to regard it as a different lead. It thins somewhat to the east, being only five inches across, east of the road. On area 28 is a one-inch lead.

Division iii: subsidiary anticline.—Between this lead and the large quarry, no veins are exposed. Here the hanging wall lead of the Jo. Taylor belt comes up steeply from the south on the south side; and on the east end where it plunges, it runs under the whin cap shown in pl. 8, fig. a. There it was gouged out for nearly 200 feet east, with a small part of the belt under it, leaving the rest of the belt and the whin cap. The foot-wall lead forms the floor of the quarry over about two-thirds of its width northward, thence sinking steeply southward on the south side and gently northward on the north. It does not sag in the syncline so much as the hanging wall lead. It is strikingly corrugated, in waves of four inches amplitude and less. The

belt contains only five leads in this quarry, and the overlying whin has thickened to nearly eight feet. The hanging wall lead dips 40° N. on the north side of the quarry, and is thinning out fast to a stringy film of quartz. Outside the whin cap on the south the Ferguson is found, two inches thick where seen.

Division iii : south anticline.—The Dreadnaught is a four-inch lead on the west, twelve inches wide eastward, breaking up more or less into angulars, and enclosed by slate. The Dry belt, sometimes called the Tripe belt, is a slate band seven to eight feet wide, with about a foot of angulars. The Moleskin is a belt of two leads, three and four inches thick, with a whin hanging wall. The Comstock, where opened on the east side of the block, is five to seven inches. South of it is a four-inch lead.

Division iii : three trenches.—Three surface cuts have been made in this block (pls. 7, 18). The attitude of the beds in them has been stated in the earlier part of this paper. In trench No. 1 (pl. 7, fig. a) only the Jo. Taylor belt is exposed. A portion of the foot-wall lead is figured in pl. 9, fig. c, to show the character of its irregularity in the western part of the division. This lead pitches east 10°, the hanging wall lead 5°. The latter is very dark and ribbony; the former is white and cellular, with much iron rust. It is here two inches thick. Immediately south of the whin overlying this belt, the Ferguson comes up at the end of the trench, very much crenulated, and averaging one and one-half to two inches thick.

In trench No. 2 (pl. 7, fig. b) the first lead lies 32 feet south of the north end, and is one inch thick, lying in a three-foot belt of slate with a dip 72° N. Lead No. 2 is at 56 feet, two inches thick, dipping 80° N. No. 3 is at 75 feet. It is a belt of two, the north one two and one-half inches, the other a zone of veinlets ; the two sets being six inches apart. It is probably the Dry belt. Whin lies on the hanging wall. No. 4 is at 79 feet, one-fourth inch thick, with a high north dip. No. 5 is a belt of three, the north one 84 feet 4 inches south, the middle

85 feet, and the south one 86 feet 3 inches. The first has a thickness of one-half inch, the second one-half to one, and the third one inch. They dip 50° N. No. 6 is the Moleskin belt. It is composed of two leads, the higher 90 feet from the north end of the trench, one-half inch thick, with a hanging wall of whin; the lower, two feet farther south, one-fourth inch thick. They dip 70° N. No. 7 is a perpendicular lead, at 96 feet, one-half to one inch thick. No. 8 is at 99 feet, a three-quarter-inch lead. No. 9 is at 100 feet, one inch thick, and appearing in places to be two leads very closely associated. No. 10 is 147 feet south, a quarter-inch curly lead, already referred to as having a double dip, lying as it does exactly on the anticlinal axis. No. 11 is at 166 feet, a large white lead, twelve to fifteen inches thick, dipping 50° S. South of the trench is the S. O. B. lead, five inches thick.

Trench No. 3 (pl. 7, fig. d), on areas 31 and 970 (block 4), was cut to overlap No. 2. South of its south end 37 feet are two two-inch leads. North from its south end 21 feet is the Hen Miller lead, six inches; at 85 feet is the Root Hog belt, with leads one, two, four and six inches thick. At 110 feet is a large lead of twelve to fifteen inches; at 131 feet a belt of two leads, three and two inches. At 154 feet is an eight-foot belt, giving leads of one, six, one, and four inches. At 172 feet is the S. O. B., six inches; and at 202 feet a large angular. At 215 feet is an eight- to ten-foot belt of slate, with leads of six and two inches. Beyond the trench, in the drain, is a three-inch lead, the South Flat; and beyond this the Smith belt, a three-inch and a two-inch lead.

Division iv.—In this division the Copper and No. 7 have never been prospected for. The Little North is here more like its condition on the west side of division iii, giving two feet of good crushing. The North Sutherland (Big North) is five inches thick on the average. South of this, owing to the structure, there are no leads which have been found to the west; and since many of the workings have been in disuse for years, or have

been poorly made, I have not data for all. The Flat lead, area 124, is three inches thick. The more northerly of the two in the center of area 77, east of the fault, is two inches thick. The Big South (wrongly called Comstock by some) is a foot thick. Two leads, six and one inch respectively, lie a few feet south of its east end. The Miller lead is three inches across. The Cowan is an erratic vein, probably not strictly in the stratification of the sediments. It varies much in thickness, running up to two feet in swells. A six-inch vein lies so close as to be included practically in the same belt. The former has a south dip, but in places appears to dip north, owing to its large corrugations. It and its belt contain much striated arsenopyrite like that in the Britannia belt, and miners have considered them equivalent; but there is no possibility that they are.

DESCRIPTION OF PLATES.

Plate 1. *Fig. a.*—Outline map of the Moose River gold district; to show general geography, location of blocks, axes of main folds, and situation of detailed map (pl. 2). Adapted from Geol. Surv. Can., doc. 624.

Fig. b.—Detailed map of "West Mine," showing the natural outcrops and artificial exposures, and the position of the anticlinal axis.

Plate 2. Detailed map of the main part of Moose River gold district; showing positions of shafts, quarries, leads, exposures of country rock, and anticlinal axes, with the attitudes of determinable strata and veins. Scale 1 : 2100, 1 inch to 175 feet.

Plate 3. Detailed cross section of division i.

Plate 4. Cross section of division ii.

Plate 5. Cross section of division iii.

Plate 6. Cross section of division iv.

Plate 7. Detailed sections from trenches and quarry on areas 30, 31, 70, 71 Block 1, and 97 Block 4. *Fig. a*, trench 1; *fig. b*, trench 2; *fig. c*, quarry; *fig. d*, trench 3.

Plate 8. *Fig. a.*—View in quarry on areas 73, 74; looking east, showing synclinal sag on the subsidiary anticline. Above the opening is the hanging wall whin overlying the Jo. Taylor belt. The opening was made in excavating the hanging wall lead, and below this lies the slate holding the other veins of that group. The foot-wall lead forms the floor of the quarry. The face is a joint plane. The cleavage, and the serration made by its intersection with stratification, are also shown.

Fig. b.—Crenulated lead; showing curving of cleavage around the arch, and inward toward the center of a trough. The white spots in the country rock are crystals of arsenopyrite. About natural size.

Fig. c.—Specimen taken from the roll of a vein; showing the stratification curving beneath the roll, and approximately parallel with it. About natural size.

Plate 9. *Fig. a.*—Section at intersection of middle fault with south anticlinal axis of the subsidiary anticline; on east side of fault, in a small pit on area 71. Black band represents the hanging wall lead of Jo. Taylor belt, changing from a south dip, and leaving the hanging wall whin.

Fig. b.—In the same pit as fig. a; section showing fault. The lead is viewed along the strike, but has little dip at this point. In these two figures, *gl* = glacial drift, *qt* = quartzite, *sl* = slate.

Fig. c.—Section at the north end of trench 1; showing crenulations in foot-wall lead of the Jo. Taylor belt (vid. pl. 7, fig. a, north end of section).

Plate 10. View in quarry on area 77, looking northeast; showing on north side of quarry the eastward pitch of the strata, and on the east wall a fault plane (cf. pl. 2)

Plate 11. Structural details.

Fig. a.—Crenulated lead, just below Jo. Taylor belt; to show relation between size of vein and amplitude of corrugation, and lack of sympathy of adjacent strata.

Fig. b.—Serration of stratification by cleavage; quarry, area 74.

Fig. c.—Crenulated angular, Kaulback belt (cf. fig. a).

Fig. d.—Irregular vein; west wall of quarry, area 73. Inclined lines show cleavage, horizontal lines stratification.

Figs. e, f.—Details of rhythmic crenulation of a lead.

Fig. g.—Diagramatic section, to show the relation between stratification, jointing, and cleavage, in the country rock adjacent to a roll. The first follows the vein closely, in full lines; the second is broadly curved, in full lines; the third is but slightly curved, in broken lines.

Fig. h.—Map of the middle fault, in the small pit at east end of quarry, area 71.

Fig. i.—Detail of crest of the south anticline in trench. 2. The heavy line indicates a lead, capped by whin and underlain by slate.

Plate 12. Details of Kaulback angulars.

Fig. a.—Section at 60-foot level, north tunnel; showing relations of angulars to stratification.

Fig. b.—Map of part of the same angulars, taken at approximately the same place; looking *up* at the roof of the tunnel.

Fig. c.—Details of rolling and splitting of a stratified portion of an angular.

Fig. d.—Details of a portion which follows the stratification approximately. Vertical lines represent cleavage.

Plate 13. Copper belt, here composed of two leads, symmetrically crenulated; looking east.

Plate 14. Big North or Great North lead, looking west in the stope on the west plunge; showing crenulation, and relations of stratification and cleavage to the lead.

Plate 15. Serpent lead, looking west on the west plunge; showing in the lead extreme contortion with crushing, and parallel banding, and twisting of cleavage under the influence of rolls.

Plate 16. Serpent lead; showing details of a thick portion.

Plate 17. *Fig. a.*—Contacts of irregular lenticles of slate in quartzite.

Fig. b.—Enlargement along line a-b.

Figs. c.-g.—Sections of vein margins, from Kaulback angulars; showing relations of gold to gangue and country rock. *Fig. e*, a portion of *fig. c* enlarged; *fig. g*, a portion of *fig. e* enlarged.

Plate 18. Map of areas 30, 31, 70 and 71, enlarged from the original of pl. 2.

THE MIRA GRANT, CAPE BRETON COUNTY, N. S.—BY EDWIN GILPIN, JR., A. M., LL. D., F. R. S. C., C. I. S. O., ETC., ETC., *Inspector of Mines.*

(Read 18th May, 1903.)

The establishment of large iron and steel producing plants at the Sydneys has led to enquiries for iron ores in Cape Breton. These establishments are practically independent of local ores, as their supplies are brought from Bell Island, in Newfoundland; but they are presumably willing to take other ores if they can be laid down equally cheaply at their furnaces. The presence of iron ore beds, in strata of Lower Silurian age, on the south shore of the Mira River, has been known for some years. The ore, a bedded red hematite, of good quality, showed signs of its presence over a tract several miles long. Recent explorations have apparently proved it to be presented in quantity permitting of economic development. Some leases were issued by the Mines Department, when it was unexpectedly found that the land on both sides of the Mira River for several miles had been granted at an early period in the history of the island as a province separate from Nova Scotia.

A judicial investigation before the Mines Department into the extent of the mineral rights under this grant appeared at one time to be unavoidable in order that the demands of rival claimants for leases, etc., might be settled. This investigation did not take place, but it appeared to the writer that a record of the data, that could be found bearing on the grant, was worth preserving for future reference.

The grant in question was issued by Lieutenant-Governor DesBarres and his council, June 26th, 1787, to Jotham White, George Rogers and their associates. White represented one

hundred loyalists who had petitioned for a grant on the shores of this beautiful sheet of water. It was then settled by a few fishermen, living near its mouth, and by a few families living higher up the river on the site of a small French settlement.

The boundaries of the grant were as follows :—

" Beginning at the north-eastern head of a cove on the north-western shore of Mira Bay, running north five degrees east three hundred and forty chains ; thence south eighty-five degrees west one thousand seven hundred and sixty chains ; thence south fifteen degrees west eight hundred and eighty chains ; thence easterly until it strikes the head of the southernmost branch which empties itself into Milward Lake ; thence through the middle of the lake northward until it bears west from the northwesternmost angle boundary of a reservation for the Crown (a naval reserve) ; thence south seventy-one degrees and thirty minutes east four hundred chains along the north-western boundary of such reservation ; thence north eighty-five degrees east nine hundred and eighty chains, until it strikes on the south-western shore of said Mira Bay at a pile of stones distant one mile easterly from the entrance of Fielding's, alias Catalogne, Lake ; thence westerly and northerly following the roundings of the shore around the head of said Mira Bay across the entrance of Mira River, continuing thence easterly until it meets the first mentioned boundary, containing in all 100,000 acres, more or less, with allowance for roads, glebe, schools, etc."

The grant included also " mines and minerals," reserving, however, " all mines of gold, silver, lead, copper and coal."

After providing for quit rent, among other conditions of settlement necessary to prevent forfeiture of the grant was the following : that the grantee should, " within three years, begin to employ thereon and continue to work for the three years then next ensuing in digging any stone quarry or mine, one good and able hand for every fifty acres."

It appears that few of the original grantees effected a permanent settlement on their allotments, and that gradually

considerable portions along the shores of the river were occupied by squatters.

About the year 1790 many highland estates in Scotland were converted into grazing lands, and the resulting overplus of population was compelled to emigrate. The tide of Scotch settlers turned towards Cape Breton in 1802, and continued until about the year 1827. Had these settlers not come to Nova Scotia, the development of the eastern part of Nova Scotia would undoubtedly have proceeded at a very slow rate. Cape Breton, at the time of their arrival, was practically a wilderness. Grants of crown lands were issued up to March 30th, 1810; after that date up to 1818, crown licenses, warrants, etc., were given. This immigration seized upon the Mira district, which appeared a fair land after the rugged hills of Scotland, although in reality the land was not found, when cleared, to prove as fertile as expected.

Settlers of all kinds were found here in addition to the representatives of the original letters patent, holders of regular grants, crown leases and licenses, warrant of survey, etc., and squatters.

The confusion of titles in the district was several times brought to the notice of the Government of Cape Breton, and later to the notice of the authorities at Halifax. Apparently matters were allowed to drift until legislation appeared necessary.

Chapter 33, acts of 1839, recited that this grant had been issued by the Government of Cape Breton in 1787, that it contained 100,000 acres, as would appear on reference to the Register of Grants, book A, pages 206, 207 and 208, that the conditions of settlement had not been observed by the original grantees, that in 1801 certain of the original grantees and others holding title under them, finding that it was impossible to have the grant divided so as to give them their full shares, petitioned to have the grant declared void so that they could obtain satisfactory deeds of their original allotments, or an equivalent

The petition was entertained and on the finding of a jury, the grant was escheated ; and a number of new grants were issued.

The act went on to declare that it was doubtful if the escheat was legal (the reasons not being given) and if the grants subsequently issued conferred legal titles thereon.

The number of the original settlers now on the grant, and of those holding under title from original settlers under the grant, was very small. A considerable number of settlers had, however, come in without title, as it appears that 1,300 people had settled on these lands, who claimed to hold by possession 55,090 acres of the grant, to have cultivated 3,064 acres, and to possess numerous live stock, besides houses, barns, etc. In order that the hopeless confusion matters had fallen into might be straightened out, it was enacted that all grants in the district in question as well as the original grant, were absolutely void, and that the title was revested in Her Majesty.

Provision was further made that it would be lawful for the Governor-in-Council, acting on the report of a commission to be appointed for the purpose, to issue free grants upon such conditions as seemed proper, within the limits of the original letters patent.

This act was reserved for the royal approval, which was presumably extended. This bold attempt at rectifying the innumerable disputes, pleased no one, as even unassailable rights were thereby placed at the mercy of an irresponsible commission, and, as was to be expected, proved impracticable, and fresh legislation was sought.

By chapter 10, acts of 1843, the act of 1839 was repealed. No further attempt was made to divide up the grant ; a declaration of rights only was enacted.

The act proclaimed (a) that all who possessed land in the Mira grant under the letters patent of 1787, and any holding under title from any of them should enjoy any such lands in fee simple.

(b) That all grants, leases, warrants of survey, or other title derived from the crown subsequently to the escheat (in 1801) were confirmed and made valid for the purpose for which they were intended.

(c) That all persons claiming under possession prior to the passing of the letters patent (the original Mira grant), howsoever such possession may have begun, should enjoy such tracts in fee simple.

(d) That all persons at the date of the passing of the act in possession, and who had been in possession for, twenty years prior to the passing of the act, holding the same adverse to any persons claiming under any of the aforesaid grants, letters patent, licenses of occupation, warrant of survey or otherwise, should enjoy such land in fee simple.

The title to the remainder of the grant, estimated to amount to between 40,000 and 50,000 acres, was revested in Her Majesty, providing, however, that the Governor in Council could consider any equitable claims of persons residing on such remainder of the grant at the date of the passing of the act, and might issue free grants to any of such persons.

This act simply left the different parties in the position of getting their rights if they fought for them.

It will have been noticed that under the terms of the original grant the iron ore passed with the soil, not being specifically reserved. The opinion prevails among all who now own land within the limits of the original Mira grant, that they own the iron ore also.

The act of 1839, appeared to have made a complete end of the grant, and of all its privileges and franchises. This act was repealed in 1843, and those occupying about half the land embraced in the letters patent were confirmed in their holdings in fee simple, no mention being made either of a grant or of a reservation of minerals. This act of 1843, being intended to be an act which defined anew rights which were suspended under the act of 1839, for the purpose of readjustment, indicated to

what extent the Crown was prepared to grant rights. It, therefore, presumably could not be construed to mean that the minerals were reconveyed as in the original grant, or in other words to mean that it conveyed more than it expressed.

This silence in the act of 1843, on the subject of minerals was apparently due to the following cause. The Duke of York on August 25th, 1826, received from the Crown of England a grant of all minerals held by the Government of Nova Scotia. By the act of 1839, repealing the Mira Grant, the land was revested in the Government of Nova Scotia, which had the power of re-granting it for the crown; the minerals, when the grant was repealed, fell directly into the grant of the Duke of York.

Finally in 1858, the grant to the Duke of York was surrendered except for the reservation to the General Mining Association of London, the purchasers of the Duke's grant, of certain tracts valuable for coal mining. Thereupon all those minerals which the action of the Crown had withdrawn from the government of Nova Scotia came again under the jurisdiction of the province.

Chapter 2 of the Acts of 1858 defined the position of the Government of Nova Scotia in respect to the minerals which had been revested in it by the surrender of the Duke's lease. It reserved out of these minerals gold, silver, lead, copper, tin, iron, coal and precious stones. It would therefore appear that in the lands covered by the limits of the original Mira Grant, the minerals recited above belong to the crown, a reservation somewhat more extended than that mentioned in the original letters patent.

Contribution to the Study of Hydroxylamine and its Salts[1].—By W. H. Ross, B. Sc., *Dalhousie University Halifax, N. S.*

(Communicated by Professor E. Mackay, 11th April, 1904.)

On account of the difficulty and expense experienced in preparing the inorganic compounds of hydroxylamine, they have not received much attention until recently. The organic compounds of hydroxylamine, however, being easier of preparation have been prepared in considerable numbers, and rather carefully studied. By the method of Divers and Haga[2] the cost and difficulty in preparing the inorganic salts of hydroxylamine have been considerably reduced Notwithstanding this, however, their preparation in a chemically pure condition is still attended with considerable difficulty. This is due to the fact that they are for the most part unstable when heated much above the ordinary temperature, and also that, like sodium salts, hydroxylamine salts do not give a precipitate with any of the ordinary inorganic reagents.

The analogy which hydroxylamine has to both water and ammonia makes it difficult to predict which it would resemble the more in its physico-chemical properties. Accordingly, at the suggestion of Dr. E. Mackay, I have undertaken the preparation of hydroxylamine and its principal inorganic salts, with a view to studying especially their electrical conductivities. The results which I have obtained on following out this suggestion form the subject matter of this paper.

Preparation of Hydroxylamine Sulphate.

The preparation of hydroxylamine sulphate was used as the starting point in the preparation of all the other compounds of

[1] It is intended that henceforth papers embodying researches carried out in the laboratories of Dalhousie College, either by students or by members of the staff shall, when published in these Transactions, appear with the general title, "Contributions from the Science Laboratories of Dalhousie University."

[2] Journ. Chem. Soc. (London), 69, 1665 (1896).

hydroxylamine. The method followed was that of Divers and Haga. To start with, 900 gms. of sodium nitrite and the corresponding amount of sodium carbonate were taken. The sulphur dioxide was prepared by acting upon copper with sulphuric acid. When this gas is passed into a mixed solution of sodium nitrite and sodium carbonate a marked rise in temperature takes place. To keep the solution cool, which is necessary in order to prevent decomposition, the vessel containing it was surrounded by ice and salt. Further precautions were taken to prevent decomposition of the solution by keeping it well stirred. The delivery tube was made to act as a stirring rod. It consisted of a piece of glass tubing shaped thus, ˥—the longer arm dipping into the liquid, while the shorter was made to pass through a cork and connected with the generating apparatus by a fairly stout piece of rubber tubing. The cork supporting this part of the delivery tube was attached to a small wooden axle, fitted near the circumference of a horizontal wheel which was driven by a small air engine. The wheel revolving carried the tube round with it, causing it to describe a circular motion in the liquid. By means of this arrangement, the liquid could be stirred much more effectively than by having the delivery tube stationary and using another rod to do the stirring. To prevent the end of the delivery tube from freezing up, a piece of copper wire was placed in that part of the tube dipping into the liquid, and then bent up almost parallel to itself and fastened loosely to the side of the vessel containing the solution. The circular motion of the delivery tube caused it to have a motion relative to the wire thus preventing it from becoming frozen up. During a part of the experiment the solution was simply surrounded with ice. As far as I could determine, the same results were obtained at this higher temperature, so long as the liquid was kept well stirred. The sulphur dioxide was passed in until the liquid became slightly acid, and the odour of the gas became perceptible. This operation took about one hour for every 100 gms. of sodium carbonate taken. The solution thus prepared was then heated gently,

after adding a few drops of sulphuric acid. Hydrolysis was found to take place quite rapidly accompanied by a marked rise in temperature. Care had to be taken not to heat the solution too strongly at first, as it had a tendency to froth over. Effervescence was seen to cease in a short time, and the liquid was then heated to 90°. To complete the second stage in the hydrolysis, it was found necessary to keep the solution at this temperature for about 55 hours. When hydrolysis was completed, was determined by adding to a small portion of the liquid, an excess of barium chloride. If on filtering and treating the filtrate with a few crystals of potassium chlorate, no cloudiness took place on boiling, then the oxyamidosulphonate was known to be wholly converted to sulphate. The liquid was heated in porcelain jars instead of glass vessels on account of their being less liable to break, and also on account of the ease with which the solution could be heated to 90°-95° without bumping.

The excess of acid in solution was neutralized by adding the required amount of sodium carbonate. This amount was calculated by titrating a small portion of the solution with a portion of the prepared sodium carbonate solution—methyl orange being used as an indicator. The neutral solution was then evaporated down until it weighed about eleven times the weight of the sodium nitrite taken. On setting aside to cool, a large amount of sodium sulphate crystals separated out. Successive crops of crystals were then removed until no further separation of crystals would take place from the mother liquor. The last evaporation was brought about at reduced pressure to prevent decomposition. The crop of crystals containing the largest proportion of hydroxylamine was then taken, dissolved in water, and successive small portions of crystals removed by evaporating off the required amount of water at reduced pressure. This was kept up until the whole of the solution was crystallized. No crop of crystals, however, was found to be entirely free from sodium. The crop of crystals richest in hydroxylamine was then taken and recrystallised a great number of times. Although

I had a large amount of the impure salt to start with, and made many crystallisations, yet I failed to obtain crystals sufficiently free from sodium to be used in determining the electrical conductivity of the salt. The purity of the salt was determined roughly by heating a few crystals on a crucible cover. The amount of sodium sulphate left behind after the hydroxylamine sulphate had been volatilised, gave a rough idea of the amount of sodium present.

The hydroxylamine sulphate obtained in this way, however, was sufficiently pure for the preparation of the other salts of hydroxylamine, and finally hydroxylamine itself. By treating a dilute standard solution of the latter with the required amount of a dilute standard solution of sulphuric acid, a solution of hydroxylamine sulphate was obtained. This solution was evaporated to dryness on the water bath, first in an open vessel and then at reduced pressure. The salt thus obtained was purified by digesting with alcohol in an upright condenser. As both hydroxylamine and sulphuric acid are readily soluble in alcohol, while hydroxylamine sulphate is not, the latter was thus obtained in perfectly pure condition by decanting off the alcohol, and repeating the process a couple of times.

Properties of Hydroxylamine Sulphate.

Hydroxylamine sulphate was obtained on crystallising from water in the form of irregular transparent crystals, which were found to be slightly hygroscopic. The melting point of the crystals was found to be about 163°. This is somewhat difficult to determine exactly, as they undergo decomposition at the same temperature. According to Lossen they melt at 170°; while Preibisch reports the melting point as being only 140°.

On heating above the melting point, the salt was found to break up into water, sulphur dioxide, nitrous oxide and ammonium sulphate—the greater part of the latter remaining behind after the other products have passed off.

The nitrous oxide was tested for by exploding with hydrogen in a eudiometer. When a spark from an induction coil was passed through the gas and hydrogen mixed in equal volumes, it was found that, after exploding, the volume of the mixed gases was reduced one-half. Taking a larger amount of hydrogen, the reduction of one volume in the same way took place. Two gms. of hydroxylamine sulphate yielded 180cc. of nitrogen under standard conditions. Hence the reaction which takes place must be represented by the equation:

$$3\,(NH_3O)_2H_2SO_4 = (NH_4)_2SO_4 + 2\,SO_2 + 8\,H_2O + 2\,N_2O.$$

Preparation of Hydroxylamine Chloride.

Hydroxylamine chloride was prepared by adding to a solution of hydroxylamine sulphate a slight excess of barium chloride. The solution was set aside over night to allow the precipitated barium sulphate to settle. The clear solution was then decanted off through a filter. On filtering a second time a perfectly clear solution was obtained. This was evaporated to dryness in the same way as the solution of hydroxylamine sulphate mentioned above. The residue left behind from the evaporation of the liquid was found to consist principally of hydroxylamine chloride, together with a little barium chloride and sodium chloride. By digesting these salts with successive small portions of absolute alcohol in an upright condenser, the hydroxylamine chloride was separated out, leaving the sodium chloride and barium chloride behind. On cooling, the hydroxylamine chloride at once began to separate out from its solution in alcohol in the form of white needle-shaped crystals. On recrystallizing from alcohol several times, crystals were obtained which gave no trace of either sodium or barium, and which volatilized completely when heated on a clean porcelain surface.

Properties of Hydroxylamine Chloride.

The crystals of hydroxylamine chloride obtained from water much resembled those of the sulphate, but were more inclined to

be tabular. The crystals from alcohol were needle-shaped, and and were found to be not hygroscopic. The melting point of the crystals was observed to be 157°. This agrees with that given in Graham-Otto's *Chemie*.[1]

Like the sulphate, hydroxylamine chloride decomposes when heated to the melting point. According to Graham-Otto,[1] the products of decomposition are:—Ammonium chloride, hydrochloric acid, water, nitrous oxide, and nitrogen. Nitrous oxide was tested for by passing an electric spark through the gas mixed with hydrogen, as in the case of the gas given off from hydroxylamine sulphate. Although the gases were mixed in different proportions, yet no explosion could be made to take place, showing the absence of nitrous oxide. Further, 2 gms. of the salt yielded 210cc. of nitrogen under standard conditions. Hence the decomposition of hydroxylamine chloride must be represented by the equation:

$$3\,NH_3O\,HCl = NH_4Cl + 3\,H_2O + 2\,HCl + N_2.$$

Preparation of Hydroxylamine Phosphate.

Hydroxylamine phosphate is only slightly soluble in cold water, and hence may be prepared by adding a saturated solution of normal sodium phosphate to one of hydroxylamine chloride. 200 gms. of the normal phosphate were dissolved in 400 cc. of water. To bring the salt into solution, it had to be heated almost to boiling. At the same time 110 gms. of hydroxylamine chloride were dissolved in 240 cc. of water. As the chloride is very soluble, this amount of the salt dissolved on simply warming the solution. It could then be cooled down to the ordinary temperature without immediately crystallising. In the same way the phosphate was cooled down to 30° or 40° by immersing in cold water. On now mixing the two solutions, crystals of hydroxylamine phosphate soon began to crystallise out in a very peculiar manner. Instead of starting at some point and branching out as in the case of most supersaturated solutions, the crystals of hydroxylamine phosphate

[1] Vol. 2, pt. 3, page 518 (5te Aufl.).

seemed to form independently throughout the liquid, and then fall to the bottom like flakes of snow. The formation of hydroxylamine phosphate thus more resembles the crystallisation of a salt from its supersaturated solution, than the formation of a precipita e in a solution where two soluble salts react so as to form an insoluble one.

About 75 gms. of the salt were obtained. On account of its being but slightly soluble in water, it can be purified with less difficulty than the other salts of hydroxylamine. Like the sulphate, however, it was found to decompose when a concentrated solution was heated to boiling. Considerable care had to be taken to prevent this when purifying the salt by recrystallising from water. On recrystallising eight times no trace of sodium was found.

Like many of the other salts of hydroxylamine, the phosphate forms supersaturated solutions of wonderful stability. On account of this property, I had considerable difficulty in first preparing the salt. The two solutions were mixed while hot. No phosphate crystallised out even when the solution was allowed to stand over night, and stirred briskly. On cooling down the solutions before mixing, as already mentioned, the salt was finally obtained.

Properties of Hydroxylamine Phosphate.

Hydroxylamine phosphate is much more soluble in hot than in cold water. It is almost insoluble in alcohol. Its crystals from water are coarsely, or finely, granular according to whether the solution from which they separate is very concentrated or less so. The crystals are not hygroscopic. When heated in a confined space they explode quite violently. Heated in a vacuum, the salt decomposes into hydroxylamine, water and pyrophosphoric acid:

$$2\,(NH_3OH)_3PO_4 = 6\,NH_3O + H_2O + H_4P_2O_7.$$

When heated in an open vessel the salt was found to decompose at about 148 into ammonia, water, phosphoric acid, normal ammonium phosphate and nitrous oxide. The relative proportion

of the products formed depend largely on the degree to which the salt is heated, and hence the reaction cannot be represented by a definite equation.

Preparation of Hydroxylamine Nitrate.

Hydroxylamine nitrate was prepared from the sulphate by adding the required amount of barium nitrate. The solution was set aside over night to allow the precipitated barium sulphate to settle. The supernatant liquid was then decanted off through a filter. On filtering a second time a perfectly clear solution was obtained. This was evaporated to a small volume on the water at a pressure of about half an atmosphere. The concentrated solution thus obtained was then tested for barium and sulphate. By adding carefully barium nitrate, or hydroxylamine sulphate, as the case required, a solution was finally obtained which gave no indication of the presence of either barium, or sulphate. This solution, on filtering, was then distilled in a small flask at a pressure of about 20 mm. At this pressure both water and hydroxylamine nitrate were found to distil over at a temperature below 50°. The distillation was continued until only a few cc. of the solution remained behind in the flask. A few cc. of the last portion of the solution distilled over was separately collected and dried over phosphorus pentoxide. The remainder of the distillate was standardised by titration with iodine, and used in determining the conductivity of the compound,—redistilled water being used to make up the solution.

On account of its explosive nature, a pure solution of the salt was only obtained after repeated trials. I first endeavoured to distill off the water by heating on the water bath at 100° and pressure of half an atmosphere, with a view to purifying the salt by crystallising from absolute alcohol. At this temperature, however, the salt exploded, leaving about 3cc. of water behind in the flask. The solution was again prepared in the same way, and, after being evaporated to a small bulk as before, was heated on a water bath at a temperature of 80°. To hasten evapora-

tion the vapour was drawn off by suction. At this temperature, with normal pressure, the nitrate exploded as before, leaving about 5cc. of water in the flask. On preparing the salt a third time, the final distillation was carried on at a pressure of 20mm., with the result that the nitrate was found to distil over with the water, as already mentioned, leaving barium nitrate or hydroxylamine sulphate, which might be present as impurities, behind in the flask.

Properties of Hydroxylamine Nitrate.

Hydroxylamine nitrate is a thick colorless liquid at the ordinary temperature. It may be solidified by placing in a freezing mixture of ice and salt. It decomposes slowly when heated to 80°. Heated more strongly it decomposes very rapidly, giving off red fumes. The products of decomposition were found to be nitric acid, water, ammonium nitrate, nitrous and nitric oxides. The nitric acid was tested for by passing through a solution of ferrous sulphate. The volumes of the gases given off depend largely on the degree to which the salt is heated.

Preparation of Hydroxylamine.

Hydroxylamine was prepared according to the method of Uhlenhuth[1] by distilling hydroxylamine phosphate in a vacuum. 20 gms. of the salt carefully purified and dried was distilled at a time. The distillation was made in a 100 cc distilling flask which was connected with an air condenser. This consisted simply of the tube of a Liebig condenser. A second distilling flask served as a receiver. This was connected directly with the glass tube—no adapter being used. The side tube of the receiver was connected by thick-walled tubing with a manometer, which was in turn connected with the air-pump. The manometer consisted of an upright glass tube one meter long, having its lower end resting in a trough of mercury. A graduated scale was placed alongside the tube. In this way any change of pressure, which might take place in the distilling

[1] Ann. Chem. (Liebig), 311, 117.

flask, could be more readily noticed than by the manometer in the air-pump. With the apparatus thus set up, the pressure could be reduced to 15 mm.

A thermometer was placd in the distilling flask so that the bulb dipped in the salt to near the bottom of the flask. Heat was applied to the flask with a free flame. At a pressure of 15-25 mm., the principal part of the hydroxylamine distilled over between 135° and 137°. This part of the distillation occupied about 20 minutes. The hydroxylamine distilled over as a colorless liquid at the rate of about 2 drops a second. A characteristic of the liquid was the small size of the drops formed. The temperature was then gradually raised to 160°. Towards the end of the operation, the temperature could be kept up to this point with considerably less heat than was applied to the flask at first. The distillation was stopped at the end of half an hour. From 20 grms. of the phosphate 5.6 grms. of hydroxylamine were obtained.

The product left in the distilling flask consisted of a thick, viscous, glass-like mass. This was found to consist of orthophosphoric acid, pyrophosphoric acid and a small amount of hydroxylamine which failed to distil over.

The greater part of the hydroxylamine obtained was dissolved in about 50cc. of water and redistilled. At a pressure of 15-25 mm. both water and hydroxylamine were found to distil over at a temperature of 33-35°. In this way a chemically pure solution of hydroxylamine was obtained, which was used to determine its conductivity. The solution was standardised by titration with iodine.

On distilling some hydroxylamine phosphate which was not chemically pure, the hydroxylamine which distilled over was of a reddish color. During the distillation, the temperature was raised to 180°, and the pressure allowed to fall to 50 mm. without explosion. Allowed to stand over night, the reddish color of the distillate was found to have entirely disappeared. The

color was, therefore, obviously due to oxides of nitrogen resulting from decomposition of the phosphate other than that which leads to the formation of hydroxylamine.

Properties of Hydroxylamine.

Hydroxylamine resembles ammonia in many of its chemical reactions. With a neutral solution of ferric chloride, it gives a precipitate of ferric hydroxide, part of the salt being reduced at the same time to the ferrous state.

Hydroxylamine also gives with salts of manganese and zinc a precipitate of the hydroxides of these metals, soluble in hydroxylamine chloride.

With salts of aluminium and chromium, it gives a precipitate of aluminium hydroxide and chromium hydroxide, insoluble in excess.

Hydroxylamine differs from ammonia in acting as a strong reducing agent. Added in excess to an acid solution of a ferric salt, the whole of the iron is reduced to the ferrous condition.

With salts of copper, it gives a precipitate of cuprous oxide on warming.

Added to a solution of mercuric chloride it first precipitates mercurous chloride, and then, on adding an excess, the latter is reduced to metallic mercury.

Added to silver nitrate, it gives a black precipitate of metallic silver.

Its behaviour towards such oxidizing reagents as potassium permanganate and potassium bichromate has been studied by Knorre and Arndt.[1]

Although hydroxylamine reacts with litmus, it was found to have no effect on either phenol-phthalein or methyl orange.

When kept in a warm room hydroxylamine slowly breaks up into ammonia, water and nitrogen.

$$3NH_3O \quad NH + 3H_2O + N_2.$$

[1] Ber. d. Chem. Ges. 33, 30 (1900).

Any decomposition is readily detected by the odour of ammonia given off, or by adding to a small portion in solution a few drops of a neutral solution of phenol-phthalein. A solution of hydroxylamine in water appears to be stable at ordinary temperatures. A portion of a solution kept for several weeks in a warm room gave no trace of a coloration when treated with a few drops of a perfectly neutral solution of phenol-phthalein.

Titration of Hydroxylamine by Iodine.

The only fairly trustworthy method for the volumetric estimation of hydroxylamine is that devised by Haga[1] and modified by Adams[2]. This volumetric estimation is performed by adding an $\frac{N}{}$ solution of iodine in potassium iodide to hydroxylamine solution in presence of di-sodium phosphate, as long as the former is bleached—using starch as indicator. Although this method gives better results than any of the others which have been suggested, yet it was found to be far from satisfactory. The end point is very hard to determine, as the blue color given with the starch fades out immediately. It was further noticed that the results obtained were influenced considerably by the amount of sodium phosphate in solution.

In the following experiments the solutions used were:—solution of hydroxylamine sulphate containing 8.2104 gms. per liter ($\frac{N}{10}$); of iodine, containing 12.685 gms. per litre ($\frac{N}{10}$); and of di-sodium phosphate, containing 59.7172 gms. per litre ($\frac{N}{2}$). The solution of iodine was standardised by copper.

According to the equation:

$$(NH_3OH)_2SO_4 + 2I_2 = 4HI + H_2SO_4 + N_2O + H_2O,$$

5cc. of $\frac{N}{10}$ hydroxylamine sulphate solution = 10cc. of $\frac{N}{10}$ iodine solution. When making the titration it was found that 5cc. of $\frac{N}{10}$ hydroxylamine sulphate would bleach 10cc. of $\frac{N}{10}$ iodine solu-

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[1] Journ. Chem. Soc. (London), 51,794 (1887).
[2] American Chem. Journ., 28,198 (1902).

tion only after adding 12cc. of $\frac{N}{2}$ Na_2HPO_4. A larger volume of sodium phosphate added gave results too high thus :—

Vol. of $(NH_3OH)_2SO_4$ taken.	Vol. of Na_2HPO_4 added.	Vol. of iodine required.
5cc.	12cc.	10.04cc.
5 "	24 "	10.96 "
5 "	36 "	11.42 "
5 "	48 "	11.63 "
5 "	60 "	11.78 "

When titrating, iodine was added until it gave with the solution a blue color lasting for a moment. The same amount of starch solution was taken for each titration—being measured from a burette. It was found that by adding unequal amounts of starch irregular results were obtained. This was due to the fact that by using a large amount of starch the blue coloration was found to fade out less quickly than with a less amount, making it almost impossible to identify the true end point in both cases.

Haga,[1] in his experiments on the volumetric estimation of hydroxylamine by iodine, used sodium acid carbonate for producing a non-acid solution. He showed that to get best results by this method, solutions (1) should not be excessively dilute ; (2) should contain very little alkali salt ; (3) should not have more carbonate added during titration than is necessary to take up the hydriodic acid formed.

To find the effect of varying the dilution of the hydroxylamine salt when in presence of sodium phosphate, I made a series of determinations varying the volume of the solution titrated from 25 cc. to 250 cc. As far as I was able to determine, this range of dilution did not produce any effect on the titration.

A series of titrations was also made with sodium sulphate present in solution. Although amounts of this salt were added

[1] Journ. Chem. Soc. (London), 51, 794 (1887).

varying from 5 cc. to 25 cc. of a fifth-normal solution, yet no effect was produced on the titration, showing that the presence of sodium salts does not effect the estimation of hydroxylamine in a non-acid solution of di-sodium phosphate.

Electrical Conductivity.

The method used in determining the electrical conductivities of solutions of hydroxylamine and its salts, was that of Kohlrausch with alternating current and telephone.

The Wheatstone bridge consisted of four resistance coils which were certified by Queen & Co. of Philadelphia to be correct to one-fiftieth of one per cent., and a platinoid bridge wire wound on a marble drum. The small induction coil used had a very rapid vibrator, and was kept in an adjoining room that its noise might not interfere with the sound minimum in the telephone. The cell in which the solutions were placed for the determination of the resistance was of the form suggested by Arrhenius. Before using, the electrodes were polished to a bright surface and then coated with platinum black. This was done by passing a current from three Edison-Lalande cells backwards and forwards between the electrodes through a solution of platinic chloride. This solution was prepared by dissolving 1 part of platinic chloride and 0.008 part of lead acetate in 30 parts of water. The current was reversed every ten minutes, and continued until the electrodes were covered with a good coating of the platinum black. To dissolve out any platinic chloride which might be adhering to them, they were suspended in boiling water for a couple of hours.

The water used in making up solutions was purified by boiling ordinary distilled water with a few grammes of barium hydroxide. The water was condensed in a block tin worm. The first portion of about 200 cc. that came off was always thrown away. The water thus purified had at 18° a mean conductivity of about 1.1×10^6, expressed in terms of mercury. Water

purified according to the method of Jones and Lindsay[1] by distilling twice, first from sulphuric acid and potassum bichromate, and then from barium hydroxide did not appear to have any greater resistance than that distilled from barium hydroxide alone.

A constant temperature was maintained by placing the cell containing the solution whose resistance was to be determined in a large vessel of tap water kept stirred by a mechanical stirrer, driven by a small hydraulic motor. The thermometer was graduated to a fiftieth, and had its errors determined at the Physikalisch-Technische Reichsanstalt, Berlin.

When starting to determine the conductivities of the hydroxylamine salts, it was noticed that with each salt the conductivity increased continually. In the case of the stronger solutions the increase in conductivity took place slowly, but rapidly when the solutions were very dilute. A one-tenth normal solution of hydroxylamine chloride was found to have the same conductivity as one made up a month before. The conductivity was also found to remain the same, although the solution was left in an open vessel for some time, showing that the change in conductivity was not due to decomposition of the salt in solution. On placing the electrodes in the solution without being joined in the circuit, the conductivity was found to have changed considerably in a few minutes. It thus became evident that the change in conductivity was due to the decomposition of the salt through the oxidizing power of the platinum black. Bright electrodes produced but little effect.

Hydroxylamine in solution was found to be oxidized by platinum black much more rapidly than its salts. 75 cc. of a one-fifth normal solution placed in a cell with the electrodes dipping in the solution were found to be completely decomposed in eighteen hours. Bright electrodes were also found to produce a considerable effect. This made an accurate determination of

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[1] American Chem. Journ., 28, 329 (1902).

its conductivity very difficult, and, as a result, the conductivities given below for hydroxylamine itself may be only approximate.

The following table shows the change in conductivity produced in one-tenth and one-hundredth normal solutions of hydroxylamine chloride by coated electrodes. The molecular conductivities (μ) are expressed in terms of mercury at 18° multiplied by 10^8 :—

$N/_{10}$ NH_3OHCl.				$N/_{100}$ NH_3OHCl.			
With current passing.		No current passing.		With current passing.		No current passing.	
Time.	μ.	Time.	μ.	Time.	μ.	Time.	μ.
0 min.	867	0 min.	867	0 min.	991	0 min	991
5 "	871			5 "	1033		
10 "	875			10 "	1074		
15 "	881	15 "	873	15 "	1106	15 "	1083
20 "	885			20 "	1131		
25 "	888			25 "	1149		
30 "	890	30 "	877	30 "	1168	30 "	1134
35 "	893			35 "	1186		
40 "	896			40 "	1200		
45 "	898	45 "	881	45 "	1213	45 "	1181

It thus appears that decomposition takes place somewhat more rapidly when the current is kept passing continuously through the solution, than when it is turned off after each reading.

On account of this change in composition, the conductivities of the solutions below had to be determined in a slightly different method from that ordinarily followed. A solution once used could not be used again to make up another solution of less concentration. This used a larger amount of each salt than I had expected, and, as a result, none of the solutions made up were saturated excepting the phosphate. One-tenth normal solutions and those of greater concentration were made up by weighing out the salt directly. One-hundredth normal solu-

tions were prepared by adding to a half-liter flask 50 cc. of the one-tenth normal solution, and then filling up to the mark with water. Those of one-twentieth and one-fiftieth normal were obtained by adding to the cell directly about 25 cc. of the one-tenth normal solution and water in the proper proportions. Solutions of greater dilution were made up in a corresponding way.

Before determining the resistance of a solution, the cell was first rinsed out twice with a solution of the same strength. It was then placed in the bath for ten minutes, in order to be brought to the same temperature, with the electrodes joined in the circuit and suspended just above the surface of the solution in the cell. The current was then turned on, the electrodes dropped into the solution, and the reading taken as quickly as possible. In this way determinations could be made accurately with coated electrodes up to one-hundredth normal. The plates were then heated very gently until they had assumed a grayish appearance. With the platinum black thus reduced the conductivities of solutions were determined up to one-thousandth normal. For solutions of greater dilution a third cell was fitted up having the electrodes nearer together. They were heated to bright redness, and then rubbed gently with a smooth cloth until almost bright.

All solutions were made up at 18°, and the conductivities determined at the same temperature within one-fiftieth of a degree. The conductivity of the water used in making up each solution was determined, and subtracted from the observed conductivity of the solution.

The constants of the cells were determined by means of standard potassium chloride solutions, the specific electrical conductivities in reciprocal ohms of $\frac{N}{10}$, $\frac{N}{20}$ and $\frac{N}{50}$ solutions, as given by Arrhenius,[1] being as follows :

k, at 18°, for $\frac{1}{10}$ normal K Cl = 0.011203.
" " $\frac{1}{20}$ " " = 0.0057875.
" " $\frac{1}{50}$ " " = 0.0023992.

[1] Electro-Chemistry, p. 135.

In the following tables, the several columns are as follows:—

(1). Grammes of salt taken per liter (g).

(2). Volume of solution per gramme molecule of salt (v).

(3). Specific equivalent conductivity at 18°, in terms of mercury, multiplied by 10^8 (μ_v).

I.

Hydroxylamine Sulphate [equivalent gramme molecule, $(NH_3OH)_2SO_4$].		
g	v	μ_v
.0082104	10000	1203
.016421	5000	1189
.041052	2000	1159
.082104	1000	1130
.16421	500	1093
.41052	200	1030
.8210	100	977
1.6421	50	920
4.1052	20	805
8.2104	10	716
16.4208	5	638
....	....	....

II.

Hydroxylamine Chloride [equivalent gramme molecule, NH_3OHCl].		
g	v.	μ_v
.006952	10000	1124
.013904	5000	1116
.03476	2000	1099
.06952	1000	1076
.13904	500	1046
.3476	200	1015
.6952	100	989
1.3904	50	958
3.476	20	909
6.952	10	866
13.904	5	805
34.760	2	733

III.

Hydroxylamine Phosphate [equivalent gramme molecule, $(NH_3OH)_3PO_4$].		
g	v	μ_v
.0065743	10000	271
.013148	5000	270
.032871	2000	268
.065743	1000	266
.13148	500	264
.32871	200	260
.65743	100	255
1.3148	50	247
3.2871	20	236
6.5743	10	220
13.1486	5	198

IV.

Hydroxylamine Nitrate [equivalent gramme molecule, NH_3OHNO_3].		
g	v	μ_v
.009611	10000	1355
.01922	5000	1340
.048055	2000	1318
.09611	1000	1298
.1922	500	1271
.48055	200	1247
.9611	100	1223
1.922	50	1191
4.8055	20	1126
9.611	10	1067
....	....	....

V.

Hydroxylamine [equivalent gramme molecule, NH_3O].		
g	v	μ_v
.03306	1000	22
.06612	500	19
.1653	200	15
.3306	100	12
6612	50	9
1.653	20	7
3.306	10	5
6 612	5	4

From the above results, it may be seen that the nitrate has a greater conductivity than the chloride, which in turn has a greater conductivity than the sulphate. This is different from what might be expected from a comparison of the corresponding salts of the alkalies. In the case of these salts, the chlorides, without exception, have a greater conductivity than the nitrates. The sulphates, however, as in the case of the hydroxylamine salt, have the lowest conductivity. When making a comparison with the salts of copper, cadmium, etc., it is seen that the nitrates, as in the case of the hydroxylamine salt, have the greatest conductivities. It seems probable, therefore, that hydroxylamine nitrate, differing from the other salts of hydroxylamine in being a liquid at ordinary temperatures, also differs from the chlorides and sulphates in its greater dissociation.

In the following table the conductivities[1] of a few salts of sodium, potassium and ammonium are given for the sake of comparison with those of hydroxylamine :—

[1] Whetham, *Theory of Solutions*, p. 407 (1902).

VI.

v	K Cl	Na Cl	NH_4Cl	NH_3OHCl	K_2SO_4	Na_2SO_4	$(NH_4)_2SO_4$
5	958	757	948	805	736	559	702
10	1047	865	1035	866	897	734	....
100	1147	962	1142	989	1098	906	....
1000	1193	1008	1190	1076	1207	998	....

v	$(NH_3OH)_2SO_4$	KNO_3	$NaNO_3$	NH_4NO_3	NH_3OHNO_3	NH_4OH	NH_4O
5	638	839	694	865	....	12	4
10	716	983	817	....	1067	31	5
100	977	1122	907	....	1223	92	12
1000	1130	1180	952	....	1298	260	22

Compared in this way, it is seen that the conductivity of the chloride and sulphate of hydroxylamine is lower than the corresponding salts of potassium and ammonium, being almost the same as sodium. It may also be noted that while the chloride and sulphate of ammonium have a lower conductivity than the corresponding salts of potassium, yet, like hydroxylamine, in the case of the nitrate it has a higher conductivity than either sodium or potassium.

No data for comparison of the conductivity of phosphates were obtainable.

From the results obtained on the conductivity of hydroxylamine in solution, it is evident that although it has a very high resistance, greater than that of ammonia, indicating weaker basicity, yet it can not be classed, like water, as a non-electrolyte.

Middleton Fungi*.—By R. R. Gates, M. A., *Middleton, N. S.*

(Read 8th September, 1902.)

The study of our Fungi is a part of botanical science to which comparatively little attention has hitherto been directed by Canadian botanists, so that Canada is reckoned as one of the regions which is still mycologically unexplored. The absence of chlorophyll, which has been brought about by the parasitic and saprophytic habits of these plants, distinguishes them from all other members of the plant kingdom; and perhaps on this account, being considered as the degenerate and depauperate representatives of a once higher type, they have been accounted of less scientific interest and economic importance than the chlorophyll-bearing plants.

Investigations of recent years have shown that a relation exists between the mycelium of fungi in the soil, and many of the higher plants. Widely occurring instances of mycorrhiza are known. Thus Janse found that out of seventy-five plants selected at random and examined, sixty-nine had mycelial hyphæ attached to their roots. These hyphæ had replaced the root hairs, root cap, and in some instances the outer layer of the root tissue. Their advantage to the plant over root hairs seems to be a matter of osmotic pressure in facilitating absorption.

We also have among Chlorophytes, examples of plants which are being still further reduced, so that the whole root has been replaced, the chlorophyll of the leaves being reduced in amount, and the whole plant becoming incipiently saprophytic. This has been called Symbiotic Saprophytism, and the isolated tropical

* This paper was read in the absence of the author by the Corresponding Secretary of the Institute, Dr. A. H. MacKay, who presented a large number of dried specimens, and the compilation of lists of Nova Scotia fungi, which appears on page 122 of this volume, with which is consolidated the list of about forty fungi determined by Mr. R. R. Gates, from the vicinity of Middleton, Annapolis County, Nova Scotia. Readers are therefore referred to Dr. MacKay's list for Mr. Gates' catalogue of species. The intoductory portian only of Mr. Gates' paper appears here, as it forms a useful introduction to Dr. MacKay's synopsis.

Lycopod, *Psilotum*, which has no true roots, and whose leaves are greatly reduced, furnishes an example. In the common Indian Pipe, *Monotropa uniflora*, owing to parasitic habits still further reduction has taken place, the chlorophyll being entirely lost.

Thus we have plants which feed holophytically, *i. e.*, obtain their nourishment wholly from inorganic materials by absorption through their roots as well as by the activity of their chlorophyll in manufacturing carbohydrates from the carbon dioxide of the atmosphere. These, of course, constitute the great mass of plants. But as we have seen, owing to the absorption of organic compounds ready prepared, by means of mycorrhiza, or on account of parasitism, the chlorophyll of a plant may be gradually reduced in amount until it finally disappears, being no longer necessary.

A similar process has taken place in the evolution of the Fungi, except that they have probably been derived from the simpler Algæ. But the evidence of the reproductive methods shows that this process of loss of chlorophyll and consequent saprophytism probably went on simultaneously in several groups of Algæ. Thus the Fungi do not constitute a single homogeneus group; but their origin has been polyphyletic.

The lowest group of Fungi, the Phycomycetes, on account of their method of sexual reproduction, are believed to be descended from the siphoneous Algæ, probably from a type allied to Vaucheria. There is, however, a great variety in the methods of both sexual and asexual reproduction in this group; but all have probably originated from the Chlorophyceæ. The Ascomycetes on the other hand shows traces of descent from the Rhodophyceæ, the evidence for which need not be presented in a simply introductory statement.

The third great group of Fungi, the Basidiomycetes, including our common mushooms and toadstools, are generally regarded a having lost all trace of a sexual reproductive process. Certain nuclear fusions which take place during the formation of the

basidium, and its basidiospores have been regarded as sexual. Strasburger objects to this view, regarding the process as merely a nutritive one, stimulating development. He holds that a second essential of fertilization is the union of *diverse* ancestral qualities, and this cannot take place between nuclei so nearly related.

Thus the question of the origin and relationships of the Basidiomycetes still remains obscure owing to their having lost a sexual method of reproduction, although in the structure of the fructification, (*i. e.*, the part bearing asexual spores), they are by far the most highly developed group of the fungi.

Brefeld and his school regard the whole class of fungi as a single one, deny the sexuality of the Ascomycetes, and derive both Ascomycetes and Basidiomycetes from the Phycomycetes. Recent investigations are, however, opposed to these views, as it has been shown that the formation of spores in the ascus by free cell formation is essentially different from the method of spore formation in the Phycomycetes.

Economically, two of the most important orders of the Basidiomycetes are the Ustilagineæ and Uredineæ. These are the cause of the destructive "smuts" and "rusts" on cereals; but they cannot be discussed further here, although their life history is of the greatest interest.

The group of Basidiomycetes which comprises the so-called higher fungi, our mushrooms and toadstools, is the *Hymenomycetes.* They are both parasitic and saprophytic, and their mycelium is widely spread in dead and living plants and in soils.

The leaf mould of our forests is permeated with it; and every fallen log is preyed upon by series of fungi in addition to the action of bacteria and weathering processes, until it is finally reduced to a shapeless mass and mingled with the soil, there to add its share to the nutritive material upon which the saprophytic fungi in the soil subsist.

The spores of parasitic fungi, or "wound parasites," as they are often called, when blown by the wind alight upon a spot on

a tree where the cambium has been broken, and germinate. Wounds of the cambium may be caused by the natural shedding of the lower limbs of a tree, by fires, by windfalls, or in other ways. In all these cases while the wound is being slowly healed over by the growth of the cambial layer it affords an excellent place of entrance for these "wound parasites." When a spore has lodged and germinated, the mycelium at once proceeds to permeate the tissues. It may continue its growth until it has ramified throughout the heart wood, and will then in some species begin its attack upon the sap wood until it has finally permeated the whole tree.

The mycelium generally grows in three directions along definite lines:—vertically, radially and tangentially. By withdrawing the moisture content from the wood it causes shrinkage, and thus the wood is broken up into tiny cuboidal blocks. This is the "doty" stage, and the tree may become so weakened as to fall a prey to wind storms which frequently "check" the heart wood. In the radial lines caused by these "checks" the mycelium in some species will grow abundantly, forming "punk."

The tree cannot resist the growth of the mycelium. Once it has found an entrance it will continue its growth slowly for many years, in some cases for a century. But the tree thus attacked is soon rendered useless for timber, and ultimately must fall. The mycelium generally continues its encroachments upon the cambium, and finally breaks out in fruiting bodies on the surface. These are the shelving hard woody fungi so frequently seen on the trunks of infected trees. The majority of these wound parasites belong to a family of Hymenomycetes known as the Polyporaceæ, characterized, as the name implies, by the presence of numerous pores on the under surface of the hymenophore.

The study of mycology then, has a very important bearing upon the science of forestry. Canada may well consider this study one of prime importance, as affording a scientific basis for helping to solve the problem of the preservation of our vast forest resources. Surely no more practical subject can engage the

attention of any one than aiding in the determination of the best means of combatting these parasitic fungi, which are destroying thousands of dollars worth of timber annually. This cannot be accomplished without a study of the life-history of these plants, their manner of entrance and the stages of their development in the tissues of the tree.

Perhaps a certain feeling of revolt at being engaged in collecting Toadstools and Puffballs, as they are commonly called, nearly all of which are generally regarded as poisonous, has deterred some from becoming mycologists. But after the first introduction to this enticing field of work the interest grows apace. The distinctions between species are often extremely perplexing, and perhaps there is no better training in keenness of observation than the determination of fungi. The great mycologist Fries has remarked that species often appear to be grouped around other species as satellites, and the various gradations of relationship which seem apparent on examination of closely similar species, is often striking.

The main characters made use of in the determination of species of Hymenomycetes are the size and shape of the fructification or hymenophore, and the particular characters of its parts. Some of these characters are the fleshy, fibrous or cartilaginous structure of the stem, whether hollow, solid, fragile, compact, spongy, etc.; of the cap or pileus, the color and shape, whether viscid, glutinous or dry, with or without a pellicle, squamulose, warty, areolate, hairy, tomentose, smooth, etc.; of the gills in the Agaricaceæ, whether adnate to stem, adnexed, free or decurrent, broad or narrow, etc. The presence or absence of an annulus on the stem, and a volva or veil, are also important generic characters. The gills of the agarics are replaced in Polyporaceæ by pores, in Hydnaceæ by spines, in the Thelephoraceæ and Clavariaceæ by a smooth hymenium or spore-bearing surface.

The trama, or interior portion of the gills, exhibits one of two characteristic appearances in cross section under the microscope. In most genera the trama is floccose, consisting entirely

of filamentous hyphæ, but the genera *Russula* and *Lactarius* have a vesiculose trama in which numbers of the hyphal branches have swelled out, forming vesicles intermingled with the filamentous hyphæ. Several genera also possess latex tubes, but these are especially well developed in the genus *Lactarius*, in which a wound causes a copious flow of "milk." This milk may be white, yellow, orange, blue, etc., or may change color on exposure to the oxygen of the air. Many species of *Lactarius* are edible and the flavor of *L. deliciosus*, which has a bright orange milk, may be inferred from its name.

The color, odor and taste of the flesh is also frequently of importance. Some genera and species are characterized by the presence of sterile cystidia and paraphyses in the hymenium, together with the club-shaped basidia which bear the spores. Four spores are usually borne on each basidium.

Thus there is a great deal of variety in the structure of the hymenophore. The spores also frequently show differences of specific value. The genera of the Agaricaceæ are generally placed in five groups, having respectively, white, pink, brown, purple-brown, and black spores. The shade and depth of color, however, vary a good deal within each group. The size, shape, and marking of the spores are also of specific importance. They may be globose, elliptical, oblong, smooth, echinulate, warty, etc., and are only microscopically visible. Their color is easily seen when they fall in quantity or any good back ground, such as white or colored paper with the proper contrast.

In regard to the various mycelia, comparatively little has yet been done to determine specific or generic characters, and perhaps in most cases none such exist. In some species, such as *Armillaria mellea*, Vahl., an agaric parasitic upon certain conifers and frequently found growing from stumps, the mycelium collects into numerous parallel strands, forming cords, the exterior of which becomes blackened with age. These are called Rhizomorphs. They may often be found as blackened cords under the bark of old trees or stumps, and were formerly considered separate fungi, and called *Rhizomorpha subcorticalis*

Sclerotia are similar brownish bodies formed on the mycelium for the purpose of resisting the effects of dry conditions. Generally, however, the vegetative mycelium consists merely of irregularly branching septate hyphæ, which in parasitic species send haustoria into the living cells of the host, and absorb their contents. Thus the mycelium affords very few characters for determination, and in the present state of our knowledge very few species can be recognized from their mycelia.

Another difficulty of determination is the great amount of variation frequently found within a species, making it almost impossible to accurately determine its limits. The color, size and shape of almost any part of the hymenophore may vary, so that the plant may be recognizable only by its general habit and by certain distinctive, though evanescent characters scarcely describable in words. Hence the great value of photographs, drawings and water colours as an aid to determination.

As has already been mentioned, the mycological flora of Canada is comparatively little known, and as new species are continually being discovered in the United States and Europe where the greatest amount of work has been done, we may look forward to a rich harvest for future Canadian mycologists.

Much is being done in the United States to popularize this subject by the formation of mycological clubs, some of which are specially devoted to the discovery and testing of the numerous and valuable edible species, and the publication of bulletins. Among popular books on the subject may be mentioned Atkinson's "Mushrooms, Edible, Poisonous, etc.", published by Andrus & Church, Ithaca, N. Y., at $3.00, and Marshall's "Mushroom Book" obtainable from Wm. Briggs, Toronto, for $3.00. These are splendidly illustrated with photographs, and will serve as the best basis for the beginner. Numerous other works, some of them in several volumes, are available for students wishing to pursue the subject in greater detail. Among these authors may be mentioned, McIlvaine (one large volume), at $5.00, Massee (four volumes), Stevenson (two volumes), and Saccardo (fifteen volumes).

Fungi of Nova Scotia: A Provisional List.—By A. H. MacKay, LL. D., F. R. S. C.

(Presented, 8th December, 1902.)

This list is partly a summation of the papers published already in the Transactions of the Institute by the late John Somers, M. D., with whom the author was collecting at Pictou; and the lists made by Mr. R. R. Gates of Middleton, Annapolis county: by Mr. J. M. Swaine at Truro and Antigonish; and by Mr. C. Stanley Bruce at Shelburne. The general classification of M. C. Cooke is followed, mainly because nearly all of the lists were made under the predominating influence of his "Hand Book of the British Fungi." It is therefore to be expected that future study may demonstrate some of the species to be merely approximately named.

Some of the genera are now being worked over anew, and even sub-divided. There is no attempt here to indicate the latest phase of the classification of our fungi. It is simply a compilation to point out to our students who are now beginning to interest themselves in the biological exploration of the Province what has already been done. It will also serve as a basis for the new work which we hope may henceforth progress more rapidly than ever before, under the stimulus of a larger number of observers who may be expected soon to test the accuracy of the determinations already made while extending the list. The future list based upon this provisional one should point out any suspected inaccuracies of determinations, and conform to the nomenclature and classification scheme of the latest generally approved scientific work on the fungi.

The papers of the late Dr. Somers referred to above are the

following in the Transactions of the Nova Scotian Institute of Natural Science :

(1). Nova Scotian Fungi. Vol. V, pp. 188-192.
(2). " " " pp. 247-253.
(3). " " " pp. 332 & 333.
(4). Additions to N. S. Fungi. Vol. VI, pp. 286-288.
(5). " " Vol. VII, pp. 18 & 19.
(6). Nova Scotian Fungi. Vol. VII, pp. 464-466.

For brevity, the authorities above named are indicated in the list as follows:—Dr. John Somers = JS; Mr. Reginald R. Gates = RRG; Mr. J. M. Swaine = JMS; C. Stanley Bruce = CSB; and Dr. A. H. MacKay = AHMK. The remarks referring to the edibility of species are based principally on McIlvaine's experiences.

The *Divisions* of the Fungi according to Cooke's classification are indicated by the capital letters of the alphabet, *e. g.*, the Sporifera = A; the *Families* by the ordinary letters, *e. g.*, *Hymenomycetes* = a; the *Orders* by Roman numerals, *e. g.*, *Agaricini* = I; and the *Genera* by Arabic numerals, *e. g.*, *Agaricus* = 1.

Division (A).—SPORIFERA.

Family (Aa).—HYMENOMYCETES.

Order (AaI).—AGARICINI.

Genus (AaI1).—AGARICUS.

(Sub-generic names used below for the old generic name.)

(White-spored.)

Sub-genus : Amanita.

Amanita vaginata Bull. Under hemlock and pine, North West Arm, Halifax, JS; Middleton, RRG. Probably *Amanitopsis vaginata* of Roze. Not poisonous.

A. adnata Smith. Under spruce, Pt. Pleasant, Halifax, JS. Probably *Amanitopsis adnata* of Roze. Not poisonous.

A. verna Bull. Prince's Lodge, near Halifax, JS. Deadly poisonous. Probably a variety of *A. phalloides*.

A. virosa Fr. Shelburne, CSB. Probably a variety of the following species, and deadly poisonous.

A. phalloides Fr. Prince's Lodge, near Halifax, JS. Under spruce, Pt. Pleasant Park, Halifax, AHMK. Antigonish and Truro, JMS. Shelburne, CSB. Deadly poisonous. Effects may not begin to be felt until from six to twelve hours after eating. No antidote for the *phallin* contained in it.

A. muscaria L. Pt. Pleasant, Halifax, Sept. and Oct., JS. Common, Pictou and Halifax counties, AHMK. Middleton, RRG. Antigonish and Truro, JMS. Shelburne, CSB. Poisonous: sulphate of atropine, 1/180 to 1/60 of a grain at a dose administered hypodermically, appears to be the best antidote for the *muscarin* contained in it.

A. strobiliformis Fr. Pictou county, AHMK. Determination doubtful.

A. spissa Fr. Under larch, Willow Park*, Halifax, Sept., JS. Not poisonous.

A. Cæsarea Scop. Antigonish and Truro, JMS. Edible; but must be carefully distinguished from *A. muscaria* and similar poisonous species

Sub-genus: Lepiota.

Lepiota procera Scop. Middleton, RRG. Edible.

L. glioderma Fr. Under spruce, Halifax, JS.

Sub-genus: Armillaria.

Armillaria mellea Vahl. On decaying stumps, Dutch Village, Halifax, JS. Pictou County, AHMK. Antigonish, JMS. Edible.

Sub-genus: Tricholoma.

Tricholoma equestre L. Under fir trees, Dutch Village, Halifax, Sept., JS. Edible when cooked.

T. transmutans Pk. Shelburne, CSB. Edible.

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*The species whose habitat is given by Dr. Somers as "Willow Park" were obtained between Willow Park and the Three-Mile House (Fairview), Halifax, not at Willow Park proper. The locality is in the vicinity of what is known as "The Willows."

T. sejunctum Sow. Woods, N. W. A., Halifax, Aug., Sept., JS. Edible.

T. rutilans Schæff. Pictou county, AHMK. Shelburne, CSB. Edible.

T. columbetta Fr. Pt. Pleasant Park woods, Halifax, under spruce, Oct., JS.

T. crassifolium Berk. Pt. Pleasant Park woods, Hfx., under spruce, Oct., JS.

T. murinaceum Bull. Dutch Village, Hfx., Sept., JS.

Sub-genus : Clitocybe.

Clitocybe candicans Fr. Common. Aug. to Oct. Pt. Pl. Park woods, Hfx., Nov., JS. Edible.

C. nebularis Batsch. Shelburne, CSB. Edible.

C. fumosa P. Pt. Pl. Park woods, Hfx., Nov., JS. Edible.

C. clavipes Pers. Shelburne, CSB. Edible.

C. opaca With. Pt. Pl. Park woods, Hfx., Nov., JS.

C. gigantea Fr. N. W. Arm woods, Hfx., Nov. ; Four-Mile-House, near Hfx., 15 inch pileus, Oct., JS, Edible when properly cooked.

C. infundibuliformis Schæff. Middleton, RRG. Shelburne, CSB. Edible.

C. flaccida Sow. Willow Park woods, Hfx., Oct., [doubtful, but described in (2)]. JS. Edible.

C. bella Fr. Pt. Pleasant, Hfx., under pines, Nov., JS.

C. laccata Scop. Common. Hfx., JS. Pictou and Dartmouth. AHMK.

Sub-genus : Pleurotus.

Pleurotus ulmarius Bull. Truro, JMS. Tender parts edible.

P. lignatilis Pers. On beech trees mostly, near Three-Mile House, Hfx., Oct., JS. Edible.

P. ostreatus Jacq. Truro, JMS. Oyster fungus. Very edible.

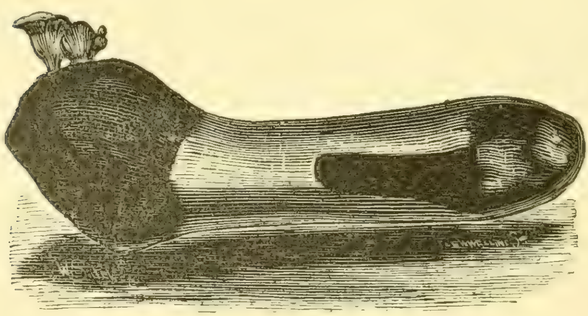
P. salignus Fr. On trunks of living poplars, Hfx., Sept., Oct., JS. Edible when young.

P. serotinus Schrad. Pictou, AMHK. Truro, JMS. Edible.

P chioneus P. On twigs, Dutch Village, Hfx., JS.

P. applicatus Bull. On small stumps, Dutch Village, Hfx., Sept., JS.

P. Coldwelli, n. sp. Described in the *Educational Review* (St. John) of March, 1891, page 172, and in the following month, page 192. Professor A. E. Coldwell found the Agaricus growing on a whale-bone in the Museum of Acadia College, Wolfville. The bone was picked up about two years before on the Yarmouth coast, and was kept for a year and a half in a cool, dark plaec in the Museum. With the specimen, the accompanying and other drawings (which have unfortunately been lost) were also sent and published. The flesh of the fungus was hard throughout, white stem and pileus, greyish underneath.



Pleurotus Coldwelli (x½) on a desicated bone of a whale.

Chas H. Peck, State Botanist of New York, to whom the specimen was sent, said in his letter of the 19th March, 1891 :—" The fungus specimen that grew on the bone of a whale reached me this morning. The habitat is certainly a curious one, and one on which I should not expect such a fungus to grow. But these plants, like others, have the power to adapt themselves to some extent to circumstances. As to the species, the specimen does not agree rigidly with any description known to me, but is apparently closely allied to *Pleurotus pantoleucus* Fr. and *P. pometi* Fr. Its spores are of the same size and

characters as the spores of these species. But for its cæspitose habit and downy stem I should unhesitatingly refer it to *P. pantoleucus.* The downy stem may be accidental, for I find this same white down developed in patches on the pileus in such a way as to make me think it is not normal there at least. *P. pometi* has similar spores and a villose stem, and in one variety is cæspitose; but its stem is radicating and the pileus more or less flaccid, so that I would sooner think your plant an unusual cæspitose form of *P. pantoleucus*, or possibly an undescribed species. If more plants develop, it might be well to note whether the velvety white down or tomentum is constant on the stem. The shape of the pileus in this specimen is strongly suggestive of the pileus of *P. pantoleucus;* but it is evidently modified by having grown in a clump, and the appearance in the figure is different; but the shape is also modified by place of growth, so that I cannot rely on this. Should other specimens develop, I would be glad to know of it, and especially if the downy stem and cæspitose habit should be modified." No further growth of the fungus has been reported.

Sub-genus: Collybia.

Collybia radicata Relh. On dead wood, Willow Park, Hfx., Oct., JS. Pictou, AHMK. Middleton, RRG. Edible.

C. platyphylla Fr. Middleton, RRG. Edible.

C. dryophila Bull. Pt. Pleasant Park, Hfx., on decaying leaves, Oct., JS. Edible.

Sub-genus: Mycena.

Mycena flavo-alba Fr. Four-Mile House woods, Hfx., Oct. (or *M, luteo-albus*), JS. Shelburne, CSB.

M. galericulata Scop. Common. Hfx., Sept., JS. Pictou, AHMK. Edible.

M. delectabilis Pk. Among moss in damp, peaty woods, Pennant, Hfx. co., JS.

Sub-genus: Omphalia.

Omphalia hepatica Batsch. Willow Park, Hfx., Sept., JS.

O. umbellifera L. Willow Park, Hfx, Sept., JS. Edible.

O. campanella, Batsch. Middleton, RRG. Edible.

O. fibula, Bull. Willow Park, Hfx., Sept., JS.

* * *(Pink-spored).*

Pluteus cervinus Shæff. Common. Hfx., Sept., JS. Edible.

Entoloma strictor Pk. Willow Park, Hfx., Sept., JS.

Clitopilus prunulus Scop. Willow Park, Hfx., Sept., JS. Edible.

Claudopus depluens, Batsch. In pastures near Melville Island, Hfx., Sept., JS.

Leptonia lampropa Fr. In pastures, Hfx., JS.

Eccilia carneo-grisea B. & Br. Common. Hfx., Sept., JS. Edible,

* * * *(Brown-spored).*

Pholiota radicans, Fr. On the roadside, Hfx., JS.

P. capistrata Cooke, Roadside, McNab's Island, Hfx., JS.

P. squarrosa Mull. On stump, Halifax Common, Oct., JS. Middleton, on the base of an apple tree, causing its decay. Strong odour of horse radish, RRG. Edible.

Hebeloma fastibile Fr. Common. Hfx., Sept., JS. Suspicious.

H. rimosum Bull. Four-Mile-House woods, near Hfx., JS.

Naucoria melinoides Fr. Willow Park, Hfx., Oct., JS.

N. nucea Bolt, Pt. Pleasant Park woods, Hfx., under spruce fir, Oct., JS.

N. pediades Fr. In open spaces, Hfx., Oct., JS. Edible.

N. semiorbicularis Bull. Willow Park, Hfx., Oct., JS. Shelburne, CSB. Edible.

Galera ovalis Fr. On cattle droppings in woods, Hfx., Nov., JS.

G. hypnorum Batsch. Halifax, Oct., JS.

* * * * *(Purple-brown-spored).*

Psalliota arvensis Schæff. Camp Hill, Hfx., Sept., JS. Edible.

P. campestris L. Everywhere in cultivated land and pastures, JS. Pictou, etc., AHMK. Middleton, RRG. Truro, JMS. Shelburne, CSB. Best generally known edible mushroom.

Pilosace eximius (?) Pk. On decaying logs. "Dingle," North West Arm, Hfx., Sept., JS.

Stropharia semiglobata Batsch. Pictou, AHMK. Middleton, RRG.

Hypholoma sublateritium Fr. Pictou, AHMK. Middleton, RRG. Edible.

H. capnoide Fr. Pt. Pl. Park, Hfx., AHMK. Edible.

H. fasciculare Hud. Pictou, AHMK. Edible when specially cooked.

Psilocybe semilanceata Fr. Growing under spruce, Pennant, Hfx. co., JS. Doubtful.

P. spadicea Schæff. Halifax, Oct., JS. Pictou, AHMK. Edible.

P. cernua Mull. Halifax, under willow, Oct., JS.

P. fœnisecii P. Willow Park, Hfx., Sept., JS.

Psathyra spadiceo-grisea Schæff. Pictou, AHMK.

* * * * * *(Black-spored).*

Panæolus separatus L. Common. Sept., JS.

P. campanulatus L. Pictou. AHMK. Doubtful.

P. retirugis Fr. Antigonish. JMS.

Psathyrella gracillis Fr. On cow droppings, pasture, Dutch Village, Hfx., Sept.; Willow Park, Hfx., Oct., JS. Edible as flavoring.

P. disseminata Fr. Among sphagnum, Willow Park, Hfx., Oct., JS. Edible as flavoring with other fungi.

Genus (Aa12).—COPRINUS.

Coprinus comatus Fr. Public Gardens, Hfx., Sept., JS. Very abundant on newly made refuse gradings, Halifax Common. Common in Halifax and Pictou counties on new rich spots of ground. A most valuable edible species AHMK. Antigonish and Truro, JMS.

C. ovatus Fr. Public Gardens, Hfx., Sept., JS. Edible.

C. sterquilinus Fr. On cow droppings in woods, Hfx., JS. Edible.

C. atramentarius Fr. Middleton, RRG. Edible.

C. micaceus Fr. Common on dung and compost, Hfx., Aug., Nov., JS. Edible.

C. domesticus (Pers.) Fr. Shelburne, CSB. Edible.

C. plicatilis Fr. In pastures, near Hfx. July, JS. Edible.

Genus (AaI3). BOLBITIUS.

Bolbitius fragilis Fr. On cow droppings, Willow Park, Hfx., Sept., JS.

Genus (AaI4).—CORTINARIUS.

Cortinarius turbinatus Fr. Pictou, Sept., Pt. Pl. Park, Hfx., AHMK. Edible.

C. collinitus Fr. Willow Park, Hfx., Sept., JS. Edible.

C. violaceus Fr. Pictou and Dartmouth, AHMK. Antigonish, JMS. Shelburne, CSB. Edible.

C. callisteus Fr. Willow Park, Hfx., Sept., JS.

C. sublantus Fr. Willow Park, Hfx., Sept., JS. Pictou, AHMK.

C. ochroleucus Fr. Pictou, AHMK.

C. anomalus Fr. Pictou, AHMK.

C. cinnamomeus Fr. In grassy spaces, Pt. Pleasant Park, Hfx., Sept., JS. Pictou, AHMK. Edible.

C. armillatus Fr. Pictou, AHMK. Edible.

C. lilacinus Pk. Willow Park, Hfx., Sept., Oct., JS. Edible.

C. albo-violaceus Pers. Pictou, AHMK. Edible.

C. Armeniacus Fr. Common. Hfx., Sept., JS.

C. *castaneus* Fr. Willow Park, Hfx., Sept., JS. Edible.

Genus (AaI5)—LEPISTA.

Lepista nuda Bull. Willow Park, Hfx., Sept., JS.

L. cinerascens Bull. Under spruce and pine, Pt. Pl. Park, Hfx., Oct., JS.

L. personata Fr. Pt. Pl. Park woods, Hfx., Sept., JS.

Genus (Aa17).—HYGROPHORUS.

Hygrophorus eburneus Fr. Under pines, Pt. Pleasant Park, Hfx., Oct., (stem swollen, volva persisting, pileus 4½ inch), JS. Edible.

H. conicus Fr. Middleton, RRG. Edible.

H. chlorophanus Fr. Dartmouth, AHMK.

H. speciosus Pk. Willow Park woods, Hfx., JS.

H. miniatus Fr. Antigonish, JMS. Edible.

Genus (Aa18).—GOMPHIDIUS.

Gomphidius glutinosus Fr., Common near Halifax, Sept., Oct.; var. *roseus* Fr. in woods, Hfx., JS. Pictou, AHMK.

G. glutinosus, var. *roseus* Krombh.

Genus (Aa19).—LACTARIUS

Lactarius torminosus Fr. Halifax, Aug., JS. Not safe.

L. uvidus Fr. Pictou, AHMK.

L. pyrogalus Fr. Pictou, AHMK.

L. plumbeus Fr. Dartmouth, Hfx., AHMK. Poisonous.

L. piperatus Fr. Halifax, JS. Pictou, AHMK. Not generally safe, unless specially cooked.

L. vellereus Fr. Halifax, JS. Pictou, AHMK.

L. resimus Fr. Antigonish, JMS.

L. deliciosus Pk. Middleton, RRG. Truro, JMS. Edible.

L. quietus Fr. In woods, Hfx., Nov., JS.

L. cyathula Fr. Fir woods, Hfx., Sept., JS.

L. affinis, Pk. In clear spaces under spruce, Pt. Pl. Park, Hfx., JS.

L. lignyotis Fr. On turfy soil under spruce (its bright crimson surface resembling fine silk plush). Pennant, Hfx. co., JS. Edible.

L. subdulcis Fr. Pictou, AHMK. Shelburne, CSB. Edible.

Genus (Aa110).—RUSSULA.

Russula adusta Fr. In pine woods, Hfx., Sept., JS. Edible when specially cooked.

R. sanguinea Fr. In pine woods, Halifax, Sept., Oct., JS. Poisonous.

R. depallens Fr. Under spruce, Hfx., JS. Edible (McIlvaine).

R. heterophylla Fr. Shelburne, CSB. Edible.

R. emetica Fr. Shelburne, CSB, Edible (McIlvaine.)

R. veternosa Fr. Pine groves, Pt. Pleasant, Hfx., Sept., JS.

Russula alutacea, Fr. Under pines, Pt. Pleasant, Hfx., Nov.; woods, Pennant, Hfx. Co., JS. Edible.

Genus (AaI11).—CANTHARELLUS.

Cantharellus cibarius Fr. McNab's Island, Hfx., Sept., JS. Pt. Pl. Park, Hfx., AHMK. Middleton, RRG. Antigonish, JMS. Shelburne, CSB. Edible.

C. aurantiacus Fr. Pictou, AHMK. Middleton, RRG. Antigonish and Truro, JMS. Edible (McIlvaine).

C. floccosus, Schw. Under pines, N. W. Arm., Hfx. Oct., JS. Middleton, RRG. Edible.

C. infundibuliformis Fr. Woods above Melville Island, Hfx., JS.

Genus (AaI13).—MARASMIUS.

Marasmius peronatus Fr. Halifax, JS. Edible after special cooking.

M. oreades Fr. Borders of woods and woodsides, Hfx., Oct., JS. Pictou, AHMK. Edible.

M. terginus Fr. Willow Park, Hfx.; Pictou, Sept., JS. & AHMK.

M. alliaceus Fr. N. W. Arm woods, Hfx., Sept., JS.

Genus (AaI14).—LENTINUS.

Lentinus lepideus Fr. Pictou, Waverley and Dartmouth, on railway sleepers, fence posts and stumps, AHMK. Edible when tender.

L. cochleatus Fr. In misshapen tufts on decaying stumps, Sherwood, [near Four-Mile-House], Hfx. co., Oct., JS. Edible when tender.

L. vulpinus Fr. Middleton, RRG.

Genus (AaI15).—PANUS Fr.

Panus dorsalis Bosc. Pictou, AHMK.

P. stypticus Fr. Pictou, Oct., JS. & AHMK. Poisonous.

Genus (AaI16).—XEROTUS Fr.

Xerotus degener Fr. On moss tussocks (very delicate, shrivelling up quickly in dry weather), woods, Pennant, Hfx. Co., JS.

Genus (AaI17).—SCHIZOPHYLLUM Fr.

Schizophyllum commune Fr. Common on dead wood, Hfx., Aug., Oct., JS. Pictou and Dartmouth, common on deadwood, AHMK. Middleton, RRG.

Genus (AaI18).—LENZITES Fr.

Lenzites betulina Fr. Common on birch and stumps, perennial, Hfx., JS. Pictou, common, AHMK. Shelburne, CSB

L. flaccida Fr. On stumps and dead trees, Hfx., JS.

L. sepiaria Fr. On pine stumps, Hfx., JS. Pictou, AHMK.

L. abietina Fr. On larch stump, Hfx., JS. Pictou, AHMK.

Order (AaII).—POLYPOREI.

Genus (AaII19) Fr.—BOLETUS.

(Arranged according to McIlvaine).

Boletus paluster Pk. Willow Park, Hfx., JS. Pictou, (*Boletinus paluster*), AHMK. Shelburne, CSB. Edible.

B. cavipes Kalchb. Shelburne (*Boletinus cavipes*) CSB. Edible.

B. pictus Pk. Shelburne (*Boletinus pictus*), CSB. Edible.

B. Clintonianus Pk. Pictou, AHMK. Not poisonous.

B. flavus, With. Common. Hfx., Sept., Oct., JS. Pictou, AHMK.

B. luteus L. Under spruce, Willow Park, Hfx., Sept., JS. Pictou, AHMK. Edible.

B. subluteus Pk. Pt. Pl. Park, Hfx., AHMK. Middleton, RRG. Edible.

B. Americanus Pk. Middleton, RRG. Caps good when properly cooked.

B. punctipes Pk. Spryfield, Hfx. Co., AHMK.

B. granulatus L. Middleton, RRG. Generally considered edible.

B. collinitus Fr. Pictou, AHMK. Edible.

B. badius Fr. Under pine and hemlock, Willow Park, Hfx., Sept., JS. Pictou, AHMK.

B. chrysenteron Fr. Middleton, RRG. Edible.

B. subtomentosus L. Spryfield, Hfx., AHMK. Edible.

B. radicans Pers. Pt. Pl. Park, Hfx., AHMK. Eaten by McIlvaine.

B. calopus Fr. Middleton, RRG.

B. retipes B. & C. Middleton, RRG. Caps edible.

B. pachypus Fr. Common in woods, Hfx., Aug.; woods, Pennant, Hfx. Co., JS. Not edible, but not known to be poisonous.

B. separans Pk. Pt. Pl. Park, Hfx., AHMK. Edible.

B. edulis Bull. Pictou and Halifax, AHMK. Antigonish and Truro, JMS. Very edible.

B. edulis, var. *clavipes*, Pk. Middleton, RRG.

B. Satanas Lenz. (?) Antigonish, JMS. Poisonous.

B. luridus Schæff. Common, Aug. to Oct., Hfx. [*B. lividus* Fr., probably a misprint in (1)], JS. Middleton, var. *erythropus*, RRG. Poisonous. Shelburne, CSB.

B. Dartmouthi, n. sp. (?) Collected 7th October on the forest covered town site by the First Lake, Dartmouth, Halifax county. Height 5cm, pileus 4cm, convex, yellowish white becoming brown towards the margin. Flesh of stem and pileus yellowish. Stem 7 to 8 mm. thick and solid, smooth with minute vertical reddish fibre like striations, becoming more slender one centimeter from the tube stratum, and reddish, showing traces of decurrent tubes. Tube stratum nearly plane with a depression

before reaching the stem beyond which the tubes become decurrent on the stem. Tube mouths red, angular, one mm. in diameter on an average. The rest of the tubes dark ochraceous. Spores 10 microns by 3 to 4, eccentrically apiculate at one end. (A. H. MacKay).

Boletus magnisporus Frost. Spryfield, Hfx. co., AHMK.

B. scaber Fr. Pictou, AHMK. Middleton, RRG. Shelburne, CSB. Edible.

B. scaber, var. *fuscus*. Middleton, RRG. Edible.

B. chromapes Frost. Under fir and spruce, Middleton, RRG. Dartmouth, AHMK. Edible.

B. gracilis Pk. Middleton, RRG. Edible when specially cooked.

B. felleus Bull. Middleton, very bitter, RRG.

B. ampliporus Pk. (?). Pictou, Oct., JS.

Genus (AaI120).—POLYPORUS Fr.

Polyporus brumalis Fr. Dalhousie, Pictou co., AHMK.

P. leptocephalus Fr. On dead wood, Willow Park, Hfx., JS.

P. perennis Fr. Pictou, AHMK. Middleton (*Polystictus perennis*) RRG.

P. circinatus Fr. Pictou, AHMK. Edible when tender.

P. picipes Fr. Halifax, Oct., JS. Middleton, RRG. Edible when tender.

P. elegans Fr. Hopewell, Pictou county, AHMK. Middleton, RRG.

P. lucidus Fr. Pictou county, Common. AHMK. Middleton, RRG. Near Halifax, H. Piers.

P. sulphureus Fr. Dalhousie, Pictou county, AHMK. Antigonish and Truro, JMS. Edible.

P. salignus Fr. On willows, Halifax Common, JS.

P. epileucus Fr. On dead birch, Dalhousie, Pictou co., AHMK.

P. chioneus Fr. Halifax, JS. Edible when young.

P. cæsius Fr. Pictou, AHMK.

P. destructor Fr. On decaying fir wood, Melville Island woods, Hfx., JS.

P. adustus Fr. Pictou, AHMK.

P. spumeus Fr. On poplars, Hfx.; Deal's, Dutch Village, Hfx., JS.

P. dryadeus Fr. Dutch Village, Hfx., JS.

P. betulinus Fr. Pictou, AHMK. Antigonish and Truro, JMS. Edible when young. On white birch, near Halifax, H. Piers.

P. applanatus Fr. Pictou, AHMK. A specimen in the provincial museum is 25 inches in diameter.

P. pinicola (Swartz) Fr. Antigonish and Truro, JMS.

P. fomentarius Fr. On birch near Truro, July, JS. Pictou, AHMK. On aspen, N. W. Arm, Hfx., H. Piers.

P. nigricans Fr. On birch, McNab's Island; on birch, "Sherwood," Four-Mile House, Hfx. co., JS.

P. ulmarius Fr. Pictou, AHMK.

P. annosus Fr. On fallen hemlock trunk near Truro, July [description given in (1) because determination was doubtful]. JS.

P. radiatus Fr. Near Melville Island, Hfx., JS. Pictou, AHMK.

P. hirsutus Fr. Common. Hfx., JS. Pictou, AHMK.

P. velutinus Fr. Pictou. AHMK.

P. versicolor Fr. On larch, hemlock, birch, etc., Hfx., JS. Pictou, Dartmouth, etc., common, AHMK.

P. zonatus Fr. Pictou, AHMK.

P. abietinus Fr. Common in spruce and hemlock, Hfx., JS. Pictou, AHMK.

P. incarnatus Fr. On rotten wood, Willow Park, Hfx., JS. Pictou, AHMK.

P. medulla-panus Fr. Dalhousie, Pictou co., AHMK.

P. vulgaris Fr. On rotten wood, Willow Park, Hfx., JS. Pictou, AHMK.

P. osseus Kalchb. Pictou, AHMK.

P. benzoinus Fr. On a hemlock stump, Dalhousie, Pictou, AHMK.

P. resinosus Fr. Pictou, AHMK.

P. biformis Fr. On old fence logs, Pictou, AHMK.

P. marginatus Fr. Pictou, AHMK.

P. borealis, Fr. On old hemlock stump, Dalhousie, Pictou, AHMK.

P. carneus Nees. On hemlock fence logs, Dalhousie, Pictou, AHMK. Middleton, RRG.

P. Pergamenus Fr. Pictou, AHMK. Middleton, RRG.

P. cinnabarinus Jacq. On dead birch, Pictou and Halifax co., AHMK.

P. albellus Pk. Willow Park, Hfx., Oct., JS.

P. ignarius Fr. On poplar, Dutch Village woods, Hfx., JS. Pictou, AHMK.

Favolus Europaeus Fr. Middleton, RRG.

Genus (AaII21).—TRAMETES Fr.

Trametes odora Fr. (?) Pictou, AHMK.

Genus (AaII22).—DAEDALEA Fr.

Daedalea quercina P. On old trunks, Hfx., JS.

D. confragosa P. On dead willows, Hfx., JS. Pictou, AHMK.

D. unicolor Fr. On stumps, Hfx., JS. Pictou, AHMK.

Genus (AaII23).—MERULIUS Fr.

Merulius lacrymans Fr. On rotten plank in a cellar, Halifax, JS. Pictou, in a cellar, AHMK.

Genus (AaII26).—POROTHELIUM Fr.

Porothelium Friesii Mont. Pictou, AHMK.

Genus (AaII27).—FISTULINA Bull.

Fistulina hepatica Fr. (?) Pictou, AHMK.

Order (AaIII).—HYDNEI.

Genus (AaIII28).—HYDNUM L.

Hydnum imbricatum L. Boar's Back, Pictou, AHMK. Edible.

H. fragile Fr. Halifax, AHMK.

H. repandum L. Near roots of pines, Pt. Pl. Park, Hfx., Sept., JS. Antigonish and Truro, JMS. Shelburne, CSB. Pictou, AHMK. Edible.

H. compactum Fr. Boar's Back, Pictou, AHMK.

H. zonatum Batsch. Pictou, AHMK. Shelburne, CSB. Good for flavoring when young.

H. coralloides Scop. Growing on a birch chopping block, found by M. Gibson, Halifax, JS. Edible.

H. erinaceum Bull. Antigonish, JMS. Edible.

Genus (AaIII29).—SISTOTREMA Fr.

Sistotrema confluens Pers. In Pt. Pleasant Park, Hfx., Oct., JS.

Genus (AaIII30).—IRPEX Fr.

Irpex tulipifera Schw. On dead branches, Willow Park, Hfx., Oct., JS.

Genus (AaIII34)—ODONTIA Fr.

Odontia fimbriata Fr. On dead wood, Willow Park, Hfx., JS.

Order (AaIV).—AURICULARINI,

Genus (AaIV36).—CRATERELLUS Fr.

C. lutescens Fr. Willow Park, Hfx., JS (?), AHMK.

C. cornucopioides Fr. (?) Willow Park, Hfx., on the ground, Oct., JS. Antigonish, JMS.

Genus (AaIV37).—THELOPHORA Fr.

T. laciniata P. Pictou, AHMK.

Genus (AaIV38).—STEREUM Fr.

S. purpureum Fr. On dead branches, Willow Park, Hfx., JS. Pictou, AHMK.

S. hirsutum Fr. Common on stumps, etc., Hfx., JS.

S. fasciatum Schw. Pictou, AHMK.

Genus (AaIV39).—HYMENOCHÆTE Lev.

H. rubiginosa Lev. Common, Hfx., JS.

H. tabacina Lev. On dead branches on ground, Hfx., Oct., JS. Pictou, AHMK.

Genus (AaIV41).—CORTICIUM Fr.

C. salicinum Fr. Pictou, AHMK.

Genus (AaIV42).—CYPHELLA Fr.

C. fulva B & Rav. On dead sticks, Willow Park, Hfx., JS.

Order (AaV).—CLAVARIEI.

Genus (AaV45).—CLAVARIA L.

C. botrytis P. Common in spruce groves, Hfx., JS. Antigonish, JMS. Edible.

C. coralloides L. On the ground, Hfx., Sept., JS. Edible.

C. cinerea Bull. Pictou, AHMK. Shelburne, CSB. Edible.

C. cristata Holmsh. Pictou, AHMK. Antigonish, JMS. Edible.

C. rugosa Bull. Pine woods, Hfx., Oct., JS. Edible.

C. aurea Schaeff. Pictou, AHMK. Edible.

C. abietina Schum. Under spruce, Hfx, JS.

C. stricta P. Pictou, AHMK.

C. pulchra Peck. Beech grove, 3-Mile House, Hfx., Oct., JS.

C. inæqualis Mull. Pine woods, Hfx., Oct., JS. Edible.

C. flava (?) Antigonish, JMS. Edible.

Order (AaVI).—TREMELINI.

Genus (AaVI49).—TREMELLA Fr.

T. lutescens Fr. Truro, JMS. Pictou, AHMK. Edible.

T. mesenterica Retz. On dead wood, Hfx., Oct., JS., AHMK.

Genus (AaVI51).—HIRNEOLA Fr.

H. Auricula-Judæ Berk. On dead trunks of white pine, Melville Island woods, Hfx., JS. Pictou, AHMK.

Genus (AaVI54.)—APYRENIUM Fr.

A. lignatile Fr. On decaying wood, Halifax, JS.

Genus (AaVI56).—DITIOLA Fr.

D. radicata Fr. On decaying birch, Melville Island woods and on pine leaves, Hfx., JS.

Family (Ab).—GASTEROMYCETES.

Order (AbVIII).—PHALLOIDEI.

Genus (AbVIII63).—PHALLUS Linn.

P. impudicus Linn. Pictou, AHMK. Shelburne, CSB.

Genus (AbVIII64).—CYNOPHALLUS Fr.

C. caninus Fr. In a drain on property of R. Morrow, Hfx., JS. Pictou, AHMK.

Order (AbIX).—TRICHOGASTRES.

Genus (AbIX68).—GEASTER Mich.

Geaster hyrometricus P. Pictou, C. B. Robinson.

Genus (AbIX69).—BOVISTA Dill.

B. plumbea P. North common, Hfx., Oct., JS. Pictou, AHMK. Edible.

Genus (AbIX70).—LYCOPERDON Tourn.

L. giganteum Batsch. R. Morrow's grounds, Hfx., Sept., JS. Edible.

L. cœlatum Fr. Common in pastures, Aug. and Sept., JS. Edible.

L. pusillum Fr. Near roots of willows, North Common, Hfx., Oct., JS.

L. saccatum Vahl. N. W. Arm, Hfx., Oct., JS. Edible.

L. cyathiforme Farlow. Pictou, AHMK. Edible.

L. echinatum, Peck. Pictou, AHMK. Edible.

L. gemmatum Fr. Common in fields and pastures, Hfx., Aug., Sept., JS. North West Arm, Hfx., AHMK. Edible.

L. pyriforme Schaeff. On stumps, Hfx., Oct., JS. Shelburne, CSB. Edible.

Genus (AbIX71).—SCLERODERMA P.

S. vulgare Fr. Common on roadsides, Hfx., Aug., JS. Pictou, AHMK. Shelburne, CSB. Edible when specially cooked.

Order (AbX).—MYXOGASTRES.

Genus (AbX74).—LYCOGALA Mich.

L. epidendrum Fr. On rotten willow stumps, Oct., Hfx., JS. Pictou, AHMK.

Genus (AbX76).—AETHALIUM Link.

Æ. septicum Fr. On dead willow stumps, Hfx., Sept., JS. Pictou, AHMK.

Order (AbXI).—NIDULARIACEI Tul.

Genus (AbXI96).—CYATHUS Pers.

C. vernicosus DC. Pictou, AHMK.

Genus (AbXI97).—CRUCIBULUM Tul.

C. vulgare Tul. On dead twigs on ground. Willow Park, Hfx., Oct., JS.

Family (Ac.)—CONIOMYCETES.

Order (AcXII).—SPHÆRONEMEI.

Genus (AcXII109).—SPHÆROPSIS Lev.

S. malorum Berk. On windfall apples, JS.

Order (AcXV.)—PUCCINÆI.

Genus (AcXV167)—PUCCINIA Pers.

P. graminis Pers. Pictou, AHMK.

Genus (AcXV168).—GYMNOSPORANGIUM D. C.

Gymnosporangium juniperi Link. "Lucyfield," Sackville, Halifax Co., Professor George Lawson.

Order (AcXVI).—CÆOMACEI.

Genus (AcXVI171).—USTILAGO.

U. carbo Tul. (*U. tritici* Jensen.) On wheat, Pictou, AHMK.

U. avenæ Jensen. On oats, Pictou, AHMK.

Order (AcXVII).—AECIDIACEI.

Genus (AcXVII182).—RŒSTELIA Reb.

R. lacerata Tul. On unripe fruit of Indian Pears *(Amelanchier Canadensis)* Hfx., JS. Sackville, Halifax Co., Prof. G. Lawson.

Family (Ad).—HYPHOMYCETES.

Order (AdXX).—DEMATIEI.

Genus (AdXX221)—CLADOSPORIUM Link.

C. dendriticum Wallr. On leaves and fruit of apples, pears and other *Rosaceæ* [Note in (4)], JS.

Order (AdXXI).—MUCEDINES.

Genus (AdXXI226).—ASPERGILLUS Mich.

A. *glaucus* Lk. Common, AHMK.

Genus (AdXXI230).—PERONOSPORA De By.

P. *infestans* Mont. Common on potato vines, AHMK.

Genus (AdXXI235).—PENICILIUM Link.

P. *crustaceum* Fr. Common, AHMK.

Division (B).—SPORIDIFERA.

Family (Be).—PHYSOMYCETES.

Order (BeXXIV).—MUCORINI.

Genus (BeXXIV265).—ASCOPHORA Tode.

A. *mucedo* Tode. Common, AHMK.

Genus (BeXXIV270).—SPORODINIA Link.

S. *dichotoma* Corda. Pictou, AHMK.

Family (Bf).—ASCOMYCETES.

Order (BfXXVIII).—ELVELLACEI.

Genus (BfXXVIII286).—MORCHELLA Dill.

M. *esculenta* Pers. Antigonish and Truro, JMS. Near Bedford, Halifax Co., H. Piers. Edible.

M. *conica* Pers. Antigonish, Truro, JMS. Edible.

Genus (BfXXVIII287).—GYROMITRA Fr.

G. *esculenta* Fr. Pictou, AHMK. Antigonish, JMS. Not safely edible.

Genus (BfXXVIII290).—MITRULA Fr.

M. *vitellina* Sac., var. *irregulare,* Pk. Antigonish, JMS. Shelburne, CSB. Edible.

Genus (BfXXVIII291).—SPATHULARIA P.

S. *velutipes* Cooke & Farlow. Antigonish, JMS. Edible.

Genus (BfXXVIII292).—LEOTIA Hill.

L. *lubrica* Pers. On ground under birch 3-Mile House, Hfx., Sept., JS. Whycocomagh, Inverness co., 25 Sept., 1902, Miss Benedict and Miss Brown. Middleton, RRG. Edible.

Genus (BfXXXVIII293).—VIBRISSEA Fr.

V. *truncorum* Fr. Melville Island woods, Hfx., JS.

Genus (BfXXVIII294).—GEOGLOSSUM P.

G. irregulare Pk. Pictou, AHMK. Edible.

Genus (BfXXVII296).—PEZIZA Link.

P. badia P. Pictou, AHMK. Edible.
P. calycina Schum. Pictou, AHMK. Edible.
P. warnei Pk. Pictou, AHMK.
P. fulgens Pers. Pictou, AHMK.
P. coccinea Jacq. Beaver Bank, Hfx. Co., Lawson.

Genus (BfXXVIII297).—HELOTIUM Fr.

H. citrinum Fr. Pictou, AHMK.

Order (BfXXX).—PHACIDIACEI.

Gvnus (BfXXX324).—HYSTERIUM Tode.

H. pulicare Pers. Pictou, AHMK.

Order (BfXXXI).—SPHÆRIACEI,

Genus (BfXXXI332).—TORRUBIA Lev.

T. entomorrhiza Fr. On larva of June Beetle, Pictou, AHMK.

Genus (BfXXXI356).—SPHÆRIA Hall.

Sphæria morbosa Schw. "Black Knot" on the plum tree (*Plowrightia morbosa*), AHMK.

Genus (BfXXXI336).—HYPOMYCES Tul.

H. lactifluorum Schw. Parasitic on fungi, Willow Park, Hfx., Sept.; and on Gomphidium, Cantherellus, near Hfx., JS. North West Arm and Dartmouth, AHMK.

Genus (BfXXXI338).—NECTRIA. Fr.

N. cinnabarina Fr. On dead twigs in garden, Dartmouth, AHMK.

Genus (BfXXXI343).—HYPOXYLON Fr.

H. concentricum Grev. On dead birches, 3-Mile House woods, Hfx., Oct., JS.
H. cohærens Fr. Pictou, AHMK.
H. verrucosum Fr. Pictou, AHMK.
H. fuscum Fr. Pictou, AHMK.

Genus.—SCORIAS.

Scorias spongiosa (Schw.) Fr. Growing on alder. Found by Mr. W. Gibson on Bedford Range, Hfx. Co. Identified by Prof. W. G. Farlow, Cambridge, Mass, U. S. A., JS. On fir leaves and branches, Yarmouth (Miss J. K. B. Kelley), AHMK. Identified by Peck.

Phenological Observations in Nova Scotia and Canada, 1902.—By A. H. MacKay, LL. D.

(Received for publication, May, 1903.)

I present in the two tables following a summary of (1) the detailed observations made in Nova Scotia, mainly through the agency of the public schools, and (2) the more general observations made throughout the Dominion of Canada.

The object sought for in the Nova Scotian public school system is the educational one; for the pupils of the schools are the observing naturalists, the teacher being the responsible compiler and recorder of the observations.

The smaller work of the general compilation and publication of the averages of local observations is only the secondary object; but the results are now deemed to be more accurate than those made by individuals only at each station.

References in my previous papers have been made to the observations collected and published by Dr. Ihne of Darmstadt from the continent of Europe; to the school observation system like our own, which is now being, with interesting results, tried in Denmark, under the inspiration of Mr. Carl Michelsen, of Skanderborg, and the practical guidance of M. J. Mathiassen; and to the Natural History Society work of British Columbia.

I have only just received the Report on the Phenological Observations of Great Britain and Ireland for 1902, by Edward Mawley, F. R. Met. Soc., F. R. H. S., which is published in the *Quarterly Journal* of the *Royal Meteorological Society*, vol. XXIX. No. 126, April, 1903. This shows an advance in the treatment of these observations over other publications seen at date; and our system of using "annual" instead of "mensual" dates is exploited in a capital series of phenochronic graphs.

Nova Scotian Phenochrons.

As these are based on about 350 schedules, it will be observed that, as a rule, a good many schedules are averaged for each of the ten meteorological or biological regions of the province. The individual schedules are annually bound up into a volume which can be utilized by weather students in the future with every facility. There are already a number of such volumes in existence. And those of the last years have, to a considerable extent, been analyzed and compiled by a staff of specialists so as to give the phenochrons of the coast, lowland and highland belts of each county. These sheets are likewise being bound up in annual volumes. The Nova Scotian table published here is merely the most generalized average of averages.

A close study of the tables showing individual observations, will create the impression that observers are not always in a position to note the phenomena of the seasons when they first appear. In this respect the observations conducted by the public schools are more accurate. For they are made by a large number of individuals travelling nearly every day to school and radiating from this central point of the community for a distance generally of about two miles. As the teachers stimulate "observing" by noting the first one who brings evidence of the first appearance of a flower, etc., there is a great deal of competitive observation on the part of the young people. This not only makes the travelling to and from school more interesting; but is found to be a great aid to general "nature study." Accuracy is assured by the bringing of the specimen to the school room when practicable.

But even in schools mistakes may occur through accident in recording, and sometimes from lack of sufficient knowledge of the natural history of the locality. In order to discover such mistakes, and to enable directions to be framed in order to minimize them, as well as for the purpose of studying and compiling regional phenochrons, the observation schedules filled in by the teacher of each school is sent to one of a staff of special-

ists. Their criticisms are annually published in the *Journal of Education of Nova Scotia*, which also contains the names of observers and number of observations made in each of the schools reporting. Under the advice of this phenological staff several changes were made in the schedules issued after 1902, which are known as the "1903 schedule."

The names and addresses of the Nova Scotian phenological staff at present are as follows :

C. B. Robinson, B. A., Science Master, Pictou Academy.

E. J. Lay, Principal, Amherst Academy.

J. E. Barteaux, Science Master, Truro Academy.

Antoinette Forbes, B. A., Windsor Academy.

Burgess McKittrick, B. A., Principal, Lunenburg Academy.

Minnie C. Hewitt, Lunenburg Academy.

G. R. Marshall, Principal, Richmond School, Halifax.

Stanley C. Bruce, Principal, Shelburne Academy.

A. W. Horner, Principal, Public School, Yarmouth.

Canadian Phenochrons.

The second table contains the observations of the following members of the Botanical Club of Canada on the dates of the first appearances of the phenomena briefly indicated only in the table, although precisely specified in the schedules for recording them ; and are published here in order to keep the series published in the Transactions of our Institute continuous. The addresses and stations of the observers are as follows, in the order of the table :

T. A. Good, Woodstock, New Brunswick ; J. M. Duncan, Charlottetown, Prince Edward Island ; John McSwain, Charlottetown, Prince Edward Island ; Dr. Cephas Guillet, Ottawa, Ontario ; Mrs. Frank E. Webster, Beatrice, Muskoka, Ontario ; Dr. J. H. Elliott, Gravenhurst, Muskoka, Ontario ; T. R. Donnelly, Pheasant Forks, Assiniboia ; Percy B. Gregson, Blackfalds, Alberta ; J. K. Henry, B. A., Vancouver, British Columbia.

The first column is the average of about 350 schedules of observations made by as many of the public schools of the province of Nova Scotia, and the active members of the club among whom the following have been sending in reports : Rev. James Rosborough, Musquodoboit Harbor, Halifax Co.; Miss Louise MacMillan, Sydney Mines, Cape Breton ; Mrs. G. Ormond Forsyth, Port Hawkesbury, Inverness Co.; and Miss Janet Keith Bruce Kelley, Yarmouth.

The last column is the average of scattered observations from about ten observers in different parts of the south of British Columbia, five being from Vancouver Island or the coast, two from the dry belt, and three from the mountain belt. These observations were made on the schedule prepared and published by the Natural History Society of the province, and were communicated to me by A. J. Pineo, Esq., B. A., of Victoria, and are published in detail in my report from the Botanical Club of Canada to the Royal Society of Canada.

NOVA SCOTIAN PHENOCHRONS, 1902.

FLOWERING AND OTHER PHENOCHRONS FOR EACH REGION OF THE PROVINCE OF NOVA SCOTIA, COMPILED FROM 350 PUBLIC SCHOOL OBSERVATION SCHEDULES.

[The phenochrons for each region (which are averages of many observations) have the fractions omitted.]

When First Seen. Regions. 1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria)	10. Inverness Slope to Gulf.	Average for Province.	Number.	Day of the year corresponding to the last day of each month. Jan ..... 31 July ....212 Feb ...... 59 Aug .... 243 March ... 90 Sept ...... 273 April.....120 Oct.........304 May.... 151 Nov.........334 June .....181 Dec 365	When Becoming Common. Average for Province.	Regions. 1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria).	10. Inverness Slope to Gulf.
94	83	98	88	101	90	88	99	93	96	93.5	1	Alnus incana, Willd	101.0	107	96	103	98	...	103	95	104	99	102
108	105	108	94	....	98	102	99	105	111	103.5	2	Populus tremuloides, Michx	112.3	120	118	114	101	....	110	106	112	111	118
186	88	90	92	90	101	101	98	98	103	94.9	3	Epigaea repens, L	107.4	103	101	103	108	107	110	109	109	112	113
113	117	115	117	121	118	120	125	121	124	119.1	4	Viola cucullata, Gray	127.0	118	126	125	126	130	128	127	131	129	129
110	114	115	115	115	115	117	123	121	123	116.9	5	V. blanda, Willd	124.9	119	122	123	124	124	125	125	130	128	129
118	115	116	111	116	115	117	124	123	117	117.1	6	Acer rubrum, L	123.8	125	122	121	119	124	124	123	129	128	123
136	127	130	132	125	127	....	....	....	146	131.8	7	Houstonia cærulea, L	139.3	....	134	135	141	138	133	....	....	....	151
120	125	114	119	....	118	121	123	140	120	122.4	8	Equisetum arvense, L	130.2	133	132	125	126	...	129	127	134	134	128
111	119	117	118	118	121	120	128	122	123	119.8	9	Taraxacum officinale, Weber	129.0	121	127	127	127	133	131	129	133	129	131
127	152	135	128	....	126	121	....	...	126	130.8	10	Erythronium Americanum, Ker.	138.1	127	156	158	134	...	130	128	....	....	135
123	117	99	130	....	....	....	....	....		117.4	11	Hepatica triloba, Chaix	123.4	129	125	102	137	....	...	..	....	....	....
120	125	129	127	126	126	132	133	130	131	128.3	12	Coptis trifolia, Salisb	135.3	129	131	133	134	136	134	139	139	138	140
116	119	114	116	117	116	119	122	119	118	117.6	13	Fragaria Virginiana, Mill	129.2	123	129	124	127	132	129	130	129	140	129
*157	163	157	164	167	165	167	178	175	172	†166.6	14	" (fruit ripe)	178.1	174	176	173	177	179	171	180	186	181	182

*Last year the date here should have been 154 instead of "114" which was a clerical error.
†The "154" of last year should have been 158.

134	139	136	138	141	140	140	148	145	150	141.2	15	Prunus Pennsylvanica, L...... ..	147.6	141	146	144	144	150	145	146	153	151	156
217	210	....	....	....	....	233	....	225	230	223.1	16	“ (fruit ripe)........	228.8	231	212		.	....	...	237	...	234	230
129	131	137	137	137	141	143	152	151	150	141.0	17	Vaccinium Penn. v. Can., Lam...	150.4	139	141	144	146	152	153	151	161	157	157
192	186	193	238	....	195	218	212	221	208	207.1	18	“ (fruit ripe).......	220.8	211	189	211	254	...	...	229	220	237	213
139	144	139	144	152	142	147	160	153	131	147.2	19	Ranunculus acris, L..............	155.9	150	151	150	153	161	154	156	168	159	157
145	143	153	153	157	158	157	161	162	164	155.3	20	R. repens, L	162.2	152	154	161	159	167	163	164	171	163	168
145	151	146	158	....	156	154	165	166	..	155.2	21	Clintonia borealis, Raf..	161.1	154	156	149	159	...	165	159	172	173	..
142	145	135	148	158	142	146	169	155	141	148.0	22	Trillium erythrocarpum, Mich....	153.2	152	152	141	155	153	149	154	170	160	145
139	144	135	148	150	148	148	163	151	147	147.4	23	Trientalis Americanum, Pursh....	154.7	149	153	146	153	154	157	152	170	158	155
151	152	151	157	159	164	160	168	161	....	158.4	24	Cypripedium acaule, Ait.........	163.3	158	158	157	166	165	166	162	173	164	..
151	158	.	170		144	158	165	177	..	160.6	25	Calla palustris, L	190.0	162	163	....	179	..	....	164	168	183	....
137	135	133	134	139	139	153	151	143	141	138.8	26	Amelanchier Canadensis, T......	145.3	144	141	139	141	146	144	142	159	150	147
191	191	....	...	...	....	204	....	189	....	191.0	27	“ (fruit ripe)........	210.6	212	207	...	...	....	..	213	. .	210	.
156	163	154	154	....	159	163	152	164	162	158.6	28	Rubus strigosus, Michx..........	166.9	166	170	161	168	...	167	172	160	168	167
205	201	206	181	....	200	207	215	212	207	203.8	29	“ (fruit ripe)...	218.0	227	218	213	....	...	212	213	220	222	217
165	165	164	160	169	165	176	....	160	170	166.1	30	Rubus villosus, Ait	173.9	175	173	173	171	..	172	180	.	169	177
231	216	225	238	...	225	234	...	253	239	232.7	31	“ (fruit ripe)........	241.4	246	229	236	246	....	228	239	...	263	244
144	145	147	146	...	151	158	167	161	142	151.4	32	Kalmia glauca, Ait..............	157.5	152	151	155	153	..	153	163	170	166	155
142	165	150	178	157	176	178	162	162	167	163.7	33	K. angustifolia, L.........	170.1	151	171	157	182	163	182	185	168	168	173
144	149	144	149	156	151	150	161	156	163	152.4	34	Cornus Canadensis, L.............	160.6	154	160	152	158	166	159	158	167	166	167
245	203	....	221	...	....	203	....	211	213	216.1	35	“ (fruit ripe)........	225.1	249	207	...	229		....	228		219	218
152	154	151	154	158	157	157	175	163	163	158.5	36	Sisyrinchium angustifolium	166.4	161	161	158	162	166	166	166	181	170	171
160	159	159	164	168	171	172	175	179	178	168.6	37	Linnæa borealis, L........	174.5	167	166	164	169	176	178	178	181	185	182
158	172	178	.	....	....	176	182	161	....	171.5	38	Linaria Canadensis, Dum..........	176.4	170	171	182	....	..	...	179	186	170	..
166	168	165	179	....	171	175	....	170	178	170.5	39	Rhinanthus Crista-galli, L...... ..	177.8	173	174	175	176	....	176	180	.	187	180
160	163	165	154	....		166	173	174	...	165.2	40	Sarracenia purpurea, L	173.8	182	169	172	159	...	173	...	182	179	...
171	171	174	173	..	164	174	183	172	161	171.5	41	Brunella vulgaris, L......	180.0	190	177	176	179	....	180	182	188	168	....
....	186	...	191	....	....	....	....	180	190	186.9	42	Epilobium angustifolium, L	198.0	206	187	.	200	....	...	...	...	197	199
182	178	175	182	....	183	179	...	187	185	181.5	43	Rosa lucida, Ehrh........	192.6	202	184	180	186	...	204	187	....	201	196
....	168	185	150	...	..	176	....	....	....	170.0	44	Hypericum perforatum, L...	173.5	..	163	190	155	....	186	...	....	...	...
162	165	167	168	172	171	170	176	173	...	169.6	45	Leontodon autumnale, L	177.4		173	173	177	182	177	176	173	186	..
136	139	136	141	146	146	144	150	144	148	143.3	46	Prunus Cerasus (cultiv.)	149.6	142	146	143	148	156	151	149	155	151	154
196	201	190	....	. .	194	200	200	....	200	197.2	47	“ (fruit ripe).......	210.4	213	112	199	. .	..	220	206	210		212
162	156	157	157	....	158	157	168	155	157	158.5	48	Cratægus Oxyacantha, L..........	164.9	169	164	162	164	....	165	165	174	161	161
155	153	155	145	....		157	....	164	....	155.2	49	C. coccinea, L..................	162.7	168	160	161	152	..	. .	164	..	170	
137	141	138	142	149	144	144	154	153	150	145.4	50	Prunus domestica (cultivated)....	151.5	143	148	146	148	154	149	150	162	160	156
141	143	142	145	152	147	147	157	150	153	147.6	51	Pyrus malus (cultivated) early ...	154.1	150	150	148	151	158	153	152	164	157	159
150	150	148	155	159	155	157	163	160	160	155.8	52	“ “ late.....	161.8	160	156	156	160	...	160	162	171	166	164
133	138	137	140	143	138	140	156	147	147	141.9	53	Ribes rubrum (cultivated)..... ..	147.9	138	144	142	146	150	146	148	163	154	149
192	199	178	197	....	....	194	....	201	195	193.7	54	“ (fruit ripe)	205.6	212	207	182	228	...	...	200	...	205	205
143	141	131	140	145	138	141	157	152	141	142.9	55	R. nigrum (cultivated)	149.4	147	146	145	147	151	146	147	162	157	146
210	200	....	221	....	...	205	....	201	203	207.1	56	“ (fruit ripe)........	214.2	219	205	. .	227	...	..	210	. .	209	214
157	157	153	159	165	159	160	172	165	162	160.8	57	Syringa vul., L (cultivated).. .	167.9	165	163	161	165	172	164	166	178	174	171
177	182	179	185	..	185	187	205	187	..	185.9	58	Solanum tuberosum, L........ ...	198.5	187	188	.	198	....	...	211	212	200	193
176	162	171	175	168	187	177	180	190	192	177.9	59	Phleum pratense L.............. .	179.3	163	168	178	183	175	156	188	190	195	197
155	159	158	158	164	160	162	172	165	172	162.6	60	Trifolium repens, L.......	170.3	164	167	165	168	171	167	171	176	175	178
149	145	154	158	154	159	162	172	164	169	159.5	61	T. pratense, L..	168.7	159	163	164	166	168	170	170	179	173	176
...	....	....	....	....	....	203	....	207	....	205.0	62	Triticum vulgare, L............	210.8	....	...	....	....	....	....	208	...	213	....

NOVA SCOTIA PHENOCHRONS, 1902—(*Continued*).

Day of the year corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	234
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec	365

When First Seen.													When Becoming Common.										
Regions.														Regions.									
1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria).	10. Inverness Slope to Gulf.	Average for Province.	Number.		Average for Province.	1. Yarmouth and Digby.	2. Shelburne, Queens, and Lunenburg.	3. Annapolis and Kings	4. Hants and South Colchester.	5. Halifax and Guysboro	6. South Cobequid Slope (S. Cumb. and Col).	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9 Bras d'Or Slope (Inv. and Victoria).	10. Inverness Slope to Gulf.
202	199	..	....	....	....	....	....	203	...	210.7	63	Avena sativa, L.	212.3	226	203	....	....	....	...	....	....	207	....
210	196	191	180	....	198	....	....	....	194	194.9	64	Fagopyrum esculentum, L.	204.6	207	199	206	....	...	206	..	.	...	...
131	136	135	137	....	146	142	..	135	...	137.5	65a	Earliest full leafing of tree.	......	...	....	....	....	....	...	...	...	....	...
158	163	161	163	.. .	174	162	....	166	175	165.2	65b	Latest " "	.....	..	....	..	....	....	...	..	...	....	....
90	104	101	107	120	105	112	101	105	100	104.6	66	Ploughing (first of season)	117.9	108	116	116	119	141	117	121	111	121	109
105	113	116	128	115	115	118	115	125	120	117.2	67	Sewing " "	126.3	119	126	129	125	125	121	128	128	132	128
103	111	119	123	111	122	119	109	118	115	115.1	68	Potato-planting "	128.9	130	123	136	136	124	137	130	121	129	123
130	124	125	140	124	125	131	130	116	109	125.5	69	Sheep-shearing "	138.9	145	135	141	149	143	136	150	142	128	122
183	183	185	190	....	190	191	213	201	200	192.9	70	Hay-cutting "	201.4	192	192	190	207	....	198	200	218	207	208
236	232	216	229	....	227	226	254	235	224	231.0	71	Grain-cutting "	239 3	242	238	229	239	236	237	238	259	242	232
255	254	251	254	251	256	264	280	266	250	258.3	72	Potato-digging "	269 3	264	269	266	266	265	268	272	279	272	272
68	65	69	90	....	72	79	60	84	68	72.7	73a	Opening of rivers "	......	...	....	...	....	....	....	....	....	...	....
69	78	76	96	....	80	79	79	82	72	78 9	73b	Opening of lakes "	......	....	....	...	....	...	....	....	....	...	....
97	96	98	96	97	96	102	107	119	123	103.0	74a	Last snow to whiten ground	......	....	...	....	....	....	. .	....	....	....	..
111	116	124	123	115	121	129	128	132	132	123.2	74b	" to fly in air	......	....	...	...	....	....	....	...	...	....	....
145	139	142	139	....	146	141	138	137	137	140.5	75a	Last spring frost—hard	......	....	...	....	....	....	....	...	...	....	....
161	139	154	164	. ..	158	156	157	155	150	154.9	75b	" " hoar	......	....	....	....	....	....	....	...	..	....	....
92	79	80	110	....	87	84	84	84	72	85.9	76a	Water in streams—highest	......	....	....	....	....	....	....	...	...	....	....
254	253	207	245	...	266	251	250	236	242	245.0	76b	" " lowest	......	....	....	....	....	....	....	...	....	...	....
262	262	270	254	262	256	266	279	264	271	264.7	77a	First autumn frost—hoar	.....	....	....	....	....	....		...	....	....	....
293	283	301	290	284	285	285	302	285	295	290.3	77b	" " hard	......	....	....	....	..	....	....	...	....	....	....
297	291	292	288	297	290	292	306	284	296	293.4	78a	First snow to fly in air	.....		....	....	....	...	....	....	....	....	....
310	315	315	322	317	393	308	317	313	311	313.1	78b	" whiten ground	......	....	....	....	...	....	...	....	....	...	....

323	344	342	341	....	....	352	357	350	362	346.5	79a	Closing of Lakes	....	....	....	....	....	....	....	....	....	....	....
331	369	345	.	....	324	375	387	....	346	351.3	79b	" Rivers	....	....	....	....	....	....	....	....	....	....	....
67	82	77	76	68	69	75	84	80	83	76.3	81a	Wild ducks migrating, N	....	....	....	....	....	....	....	....	....	....	....
268	299	300	311	....	278	286	270	314	329	295.1	81b	" " " S	....	....	....	....	....	....	....	....	....	....	....
81	81	76	77	64	71	68	80	85	77	76.1	82a	" geese " N	....	....	....	....	....	....	....	....	....	....	....
314	333	320	302	316	293	311	....	313	291	310.3	82b	" " " S	....	....	....	....	....	....	....	....	....	....	....
81	86	93	89	87	76	82	78	95	87	85.4	83	Melospiza fasciata, North	....	....	....	....	....	....	....	....	....	....	....
74	77	71	78	78	75	76	76	87	90	78.3	84	Turdus migratorius "	....	....	....	....	....	....	....	....	....	....	....
70	88	68	80	76	76	....	84	....	90	79.1	85	Junco hiemalis "	....	....	....	....	....	....	....	....	....	....	....
99	127	112	118	134	124	138	116	124	147	124.0	86	Actitis macularia "	....	....	....	....	....	....	....	....	....	....	....
122	109	122	97	...	74	..	112	113	108	107.0	87	Sturnella magna "	....	....	....	....	....	....	....	....	....	....	....
118	127	131	123	115	115	122	118	103	140	121.3	88	Ceryle Alcyon "	....	....	....	....	....	....	....	....	....	....	....
112	138	135	147	144	141	...	....	142	138	137.2	89	Dendrœca coronata "	....	....	....	....	....	....	....	....	....	....	....
133	138	137	151	143	136	147	138	138	141	140 2	90	D. æstiva "	....	....	....	....	....	....	....	....	....	....	....
111	96	101	106	104	108	80	110	105	11	103.5	91	Zonotrichia alba "	....	....	....	....	....	....	....	....	....	....	....
143	143	140	142	142	141	145	153	155	156	146 1	92	Trochilus colubris "	....	....	....	....	....	....	....	....	....	....	....
....	164	136	134	....	125	139	....	146	128	138.7	93	Tyrannus Carolinensis "	....	....	....	....	....	....	....	....	....	....	....
....	146	131	136		135	145	123	120	126	132 9	94	Dolychonyx oryzivorus "	....	....	....	....	....	....	....	....	....	....	....
....	148	136	132	138	136	....	119	121	132	132.8	95	Spinis tristis "	....	....	....	....	....	....	....	....	....	....	....
....	106	155	123	....	151	....	94	136	....	127.7	96	Setophaga ruticilla "	....	....	....	....	....	....	....	....	....	....	....
....	152	....	156	....	120	...	130	....	131	138.0	97	Ampelis cedrorum "	....	....	....	....	....	....	....	....	....	....	....
133	128	128	129	127	129	...	102	125	138	126.7	99	Chordeiles Viginianus "	....	....	....	....	....	....	....	....	....	....	....
83	82	86	89	92	92	91	96	102	98	91.1	98	First piping of frogs	....	....	....	....	....	....	....	....	....	....	....
86	90	100	102	101	108	102	111	108	108	101.7	100	First appearance, snakes	....	....	....	....	....	....	....	....	....	....	....

THUNDERSTORMS—PROVINCE OF NOVA SCOTIA—REGIONS 1 TO 10.

OBSERVATION STATIONS—YEAR 1901.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.
237^{5} 245^{1} 246^{4} 247^{1} 250^{2} 256^{1} 259^{2} 260^{1} 273^{1} 288^{1} 314^{1}	237^{6} 246^{1} 250^{1} 255^{1} 257^{1} 258^{3} 265^{1} 268^{1} 279^{1}	237^{2} 244^{1} 247^{1} 250^{2} 251^{2} 256^{1} 258^{4} 259^{2} 304^{1}	237^{2} 238^{2} 250^{1} 251^{3} 256^{1} 273^{1} 287^{1}	237^{1} 251^{2} 255^{1} 259^{2} 261^{1} 288^{1}	250^{2} 251^{10}	238^{1} 250^{3} 251^{22} 252^{1} 256^{9} 258^{1} 259^{1} 265^{1} 290^{2}	250^{1} 251^{2} 252^{1} 256^{3} 319^{3}	251^{2} 252^{1} 256^{2} 258^{1} 290^{1}	251^{1} 253^{2} 256^{2} 257^{1} 304^{1}

OBSERVATION STATIONS—YEAR 1901.

1 Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.
198^{1} 203^{1} 205^{1} 212^{1} 220^{1}	189^{1} 190^{2} 191^{1} 196^{2} 197^{1} 198^{1} 199^{1} 201^{1} 222^{1} 204^{1} 212^{1} 220^{1} 231^{1} 235^{2}	183^{1} 189^{2} 196^{2} 197^{1} 212^{1} 220^{1} 222^{1} 223^{1}	182^{1} 183^{1} 212^{1} 218^{1} 229^{1}	182^{1}	182^{2} 192^{2} 196^{2} 197^{4} 220^{2}	182^{17} 183^{6} 189^{5} 197^{2} 198^{2} 208^{1} 209^{1} 212^{2} 215^{1} 219^{1} 228^{2} 230^{1}	183^{1} 227^{1}	191^{1} 196^{1} 199^{2} 203^{2} 205^{1} 212^{1} 213^{1} 221^{2} 222^{1} 228^{1}	182^{1} 196^{1} 203^{1} 212^{1} 213^{1} 221^{2} 223^{1} 228^{2}

The index figure above indicates the number of stations from which thunder was reported.

THUNDERSTORMS—PROVINCE OF NOVA SCOTIA—REGIONS 1 TO 10.

Observation Stations—Year 1902.									
1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.
129	129^{6}								
	130		130						
			133			141^{3}	141	133	
			142^{2}		142^{2}	142^{2}		139	
143^{2}	143^{5}	143^{25}	143^{9}		143^{9}	143^{27}	143^{2}	143	143^{2}
144^{8}	144^{38}	144^{5}	144^{14}	144^{16}	144^{3}	144^{11}	144^{5}	144^{6}	144^{3}
145	145^{7}					145	145	145^{3}	145^{2}
	146		146^{2}			147	146		
					148	148^{2}	148		
					152	151^{2}			
		153	153^{5}	153	153^{13}			153	
154^{4}	154^{9}	154	154		154^{2}		154^{3}		
155^{6}	155^{37}		155^{4}	155^{15}	155		155^{3}		155^{2}
157^{3}	156								156
160	158	161^{2}	158						157
161^{2}	159	162			162		162		
164	162^{3}	164							
166	166^{2}								
167^{6}	167^{15}	167^{2}		167^{4}					
168^{5}	168^{6}	168^{3}	168^{5}	168^{9}	168	168^{6}			
	170				169	169^{2}		169	
	171^{26}	171^{9}		170		171		171	
	173	172				173			
	174	173				174^{3}		174	174
175	175		175^{7}	175^{4}		175^{29}		175^{6}	175^{2}
	176^{38}	176^{2}	176^{16}	176^{8}		176^{7}	176	176^{3}	176^{5}
177^{2}		177^{5}	177			178^{4}		177^{2}	177
			179		197	181		178	

Observation Stations—Year 1902.									
1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.
33^{3}	49		34			42			
	68								
	77					71			
	78	81^{2}	80			87		89	89
	85	90		90	88	88	90	90^{8}	90^{2}
	92		92		92^{5}		91^{4}	91^{3}	91^{3}
	94				93				
	96		96					96	
	99^{19}	99							
	100^{2}	101				101			
	103^{38}	103^{11}		103	103				
	104				104				
	105								
	106								
	107					107			
			109			109^{3}			
	110				110	110^{2}			
111		111^{2}			111^{3}	111^{30}			
112	112^{45}	112^{13}				112^{2}			
		113				113	113	113^{2}	
114						114^{6}	114	114^{3}	
			115			115^{3}			115^{2}
116^{17}	116^{34}	116^{21}	116^{18}	116^{7}	116^{19}	116^{30}	116	116^{2}	116^{4}
117	117	117^{2}	117^{3}		117^{6}	117^{3}		117^{3}	117
				118		118			118
126	121	123				120			
127^{7}	127^{71}	125				127			
		128^{2}	128			128			

The index figure above indicates the number of stations from which thunder was reported.

CANADIAN PHENOCHRONS, 1902.

Observation Stations—When First Seen.

Number.	Day of the year 1902 corresponding to the last day of each month. Jan .... 31 July. .....212 Feb........ 59 Aug.......243 March..... 90 Sept.......273 April ...... 120 Oct........304 May.... ..151 Nov ....334 June ......181 Dec..... ..365	Average dates for Nova Scotia.	Woodstock, N. B.	Charlottetown. P. E. I. (1)	Charlottetown, P. E. I. (2).	Ottawa, Ont.	Beatrice, Muskoka, Ont.	Muskoka, Ont.	Pheasant Forks, Assa.	Blackfalds, Alberta	Vancouver, B. C.	Average dates for British Columbia.
1	Alnus incana, Willd....	93.5	*95	116	123	97	87	...	....	....	*d*59	*d*108.7
2	Populus tremuloides, Mx......	103.5	*102	....	127	96	*99	....	137	135	....	......
3	Epigæa repens, L.............	94.9	....	76	107	*106	...	99	....	..	...	.....
4	Viola cucullata, Gray........	119.1	*102	117	...	132	*110	114	137	123	*e*97	.....
5	V. blanda, Willd	116.9	*102	117	....	120	*112	103	140	....	100	......
6	Acer rubrum, L...............	117.1	*115	121	123	96	*110	107	....	....	*f*92	.....
7	Houstonia cærulea, L..........	131.8	...	....	....	....	....	....	....	....	...	......
8	Equisetum arvense, L.........	122.4	....	....	....	104	*142	....	....	....	80	......
9	Taraxacum officinale, Web....	119.8	122	120	130	109	*126	112	138	195	....	......
10	Erythronium Amer., Ker.....	130.8	*122	....	....	108	*142	112	....	....	....	......
11	Hepatica triloba, Chaix........	117.4	...	....	..	86	...	87	....	....	...	......
12	Coptis trifolia, Salisb..........	128.3	*143	....	....	120	*142	123	....	....	....	......
13	Fragaria Virginiana, Mill.....	117.6	125	147	138	111	*161	120	127	156	..	102.8
14	" (fruit ripe)....	166 6	...	....	..	161	....	...	183	200	..	153.
15	Prunus Pennsyl., L.	141.2	143	....	....	127	*138	133	147	143	*g*116	....
16	" (fruit ripe)....	223.1	..	232		....	....	...	....	223	....	.....
17	Vaccinium Penn., Lam... ..	141 0	145	....	...	119	....	123	....	....	..	128
18	" (fruit ripe)....	207.1	....	....	....	.. .	*216	....	....	219	....	185.1
19	Ranunculus acris, L...... . ..	147.2	149	166	....	140	*156	153	120	170	*130	119.6
20	R. repens, L.....	155.3	151	127	....	154	...	...	....	....	125	......
21	Clintonia borealis, Raf........	155.2	...	....	....	....	....	145	....	...	....	......
22	Trillium erythrocarpum.......	148.0	*143	....	....	125	*130	138	...	....	....	......
23	Trientalis Ameri., Pursh......	147.4	.	145	....	137	....	141	....	....	*h*124	......
24	Cypripedium acaule, Ait......	158.4	....	....	....	137	*163	142	.. .	*b*170	...	*k*121.8
25	Calla palustris, L.............	160.6	...	....	....	164	*156	....	....	....	...	......
26	Amelanchier Canadensis......	138.8	....	147	....	120	*126	124	144	*c*143	...	*c*123.5
27	" (fruit ripe)...	194.0	....	....	....	....	.. .	....	....	205	....	......

*When becoming common. *a* Rosa blanda *b* Cypripedium hirsutum.
c A. alnifolii. *d* Alnus rubra. *e* Viola palustris. *f* A. macrophyllum.
g Prunus emarginata. *h* Trientalis Europæa. *k* Calypso.

CANADIAN PHENOCHRONS, 1902.

Observation Stations—When First Seen.

Number.	Day of the year 1902 corresponding to the last day of each month. Jan ..... 31 July ..... 212 Feb ..... 59 Aug ..... 243 March ..... 90 Sept ..... 273 April ..... 120 Oct ..... 304 May ..... 151 Nov ..... 334 June ..... 181 Dec 365	Average dates for Nova Scotia.	Woodstock, N. B.	Charlottetown, P. E. I. (1).	Charlottetown, P. E. I. (2).	Ottawa, Ontario.	Beatrice, Muskoka, Ont.	Muskoka, Ont.	Pheasant Forks, Assa.	Blackfalds, Alberta	Vancouver, B. C.	Average dates for British Columbia.
28	Rubus strigosus, Michx	158.6	...	...	...	151	*166	151	170	180	*i*69	*i*141.6
29	" (fruit ripe)	203.8	...	...	...	...	*211	...	...	210	149	196.
30	Rubus villosus, Ait	166.1	...	...	...	153	*166	155	...	...	...	...
31	" (fruit ripe)	232 7	...	...	...	...	*222	...	...	...	...	...
32	Kalmia glauca, Ait	151.4	...	...	...	171	...	142	...	...	*122	...
33	K. angustifolia, L	163.7	...	...	...	171	...	...	...	...	...	...
34	Cornus Canadensis, L	152.4	...	147	...	142	*166	142	...	...	127	*l*133.2
35	" (fruit ripe)	216.1	...	...	...	...	...	...	...	...	...	...
36	Sisyrinchium angustifol	158.5	...	...	...	148	...	181	173	160	...	...
37	Linnæa borealis, L	168.6	...	...	...	160	*193	...	...	...	...	137.7
38	Linaria Canaden., Dum	171.5	...	...	...	176	...	196	...	...	...	...
39	Rhinanthus Crista-galli, L	170 5	...	...	...	...	...	...	...	...	...	...
40	Sarracenia purpurea, L	165 2	...	...	...	171	*163	176	...	...	...	...
41	Brunella vulgaris, L	171.5	...	...	...	160	*176	166	...	...	...	179.7
42	Epilobium augustifolium	186 9	...	...	...	...	*192	181	...	200	*171	177.
43	Rosa lucida, Ehrh	181.5	...	...	...	...	...	*a*166	168	173	*j*141	*j*142.6
44	Hypericum perforatum, L	170.0	...	...	...	...	*193	186	...	200	...	...
45	Leontodon autumnale, L	169.6	...	168	...	...	*310	...	...	206	...	...
46	Prunus Cerasus (cultiv.)	143.3	...	147	145	...	...	...	...	...	103	...
47	" (fruit ripe)	197.2	...	...	...	...	...	...	...	...	159	...
48	Cratægus Oxyacantha, L.	158.5	...	167	...	...	...	...	...	...	...	151
49	C. coccinea, L	155.2	...	158	163	140	*133	...	151	...	...	...
50	Prunus domestica (cult'd)	145.4	...	147	...	125	...	...	158	...	97	...
51	Pyrus malus (cult'd) early.	147 6	...	150	154	132	*144	...	...	...	114	128.6
52	" " late	155.8	...	...	...	...	...	...	...	...	...	...
53	Ribes rubrum (cultivated)	141.9	...	...	...	...	*131	...	144	...	91	113.9
54	" (fruit ripe)	193 7	...	...	...	193	...	...	...	...	...	...
55	R. nigrum (cultivated)	142.9	...	...	...	...	*134	...	149	...	...	...

* When becoming common. *a* Rosa blanda. *i* Rubus spectabilis. Rosa. *l* C. nutallii.

CANADIAN PHENOCHRONS, 1902.

Observation Stations—When First Seen.

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56	R. nigrum (fruit ripe)	207.1	....	.. .	....	193	...	....	....	....	....	132 6
57	Syringa vulgaris, L (cult.).....	160 8	....	161	163	195	146	....	163	....	123	165.6
58	Solanum tuberosum, L........	185.9	...	....	....	....	....	..	...	200	....	178.4
59	Phleum pratense, L	177.9	....	...	....	....	.. .	....	....	180	....	137.5
60	Trifolium repens, L............	162 6	....	....	....	143	....	144	....	170	125	144.8
61	T. pratense, L..................	159.5	....	180	....	151	....	152	....	....	133	180.
62	Triticum vulgare, L............	205 0	....	....	....	....	....	....	....	205	...	......
63	Avena sativa, L..............	201.7	....	....	....	...	....	....	....	205	....	......
64	Fagopyrum esculentum, L....	194.9	....	....	....	177	....	192	...	....	...	......
65a	Earliest full leafing of tree....	137.5	....	....	....	....	140	....	....	....	....	......
65b	Latest " "	165.2	....	....	....	....	....	.. .	....	....	....	......
66	Ploughing (first of season)....	104.6	....	....	....	90	*121	...	113	97	....	......
67	Sowing " "	117.2	..	106	113	....	....	....	121	97	....	......
68	Potato-planting "	115.1	....	113	....	....	*136	...	147	123	....	......
69	Sheep-shearing "	125.5	100	....	...	..	*132	...	153	175	....	......
70	Hay-cutting "	192.9	....	....	....	....	205	....	....	200	....	......
71	Grain-cutting " ...	231.0	....	231	232	....	234	..	240	....	....	......
72	Potato-digging "	258.3	....	....	....	...	262	....	....	205	....	......
73a	Opening of rivers "	72.7	....	5	67	95	....	....	83	101	....	... ..
73b	Opening of lakes "	78.9	....	....	....	....	....	....	....	120	....	......
74a	Last snow to whiten ground..	103.0	....	133	....	....	148	....	....	153	....	98.2
74b	" to fly in air.........	123.2	....	...	....	92	148	.. ..	...	153	81	.....
5a	Last spring frost—hard........	140.5	....	....	....	129	149	....	....	144	89	......
5b	" " hoar......	154.9	....	141	154	....	....	....	....	144	115	......
6a	Water in streams—highest ...	85.9	...	....	....	....	312	....	....	186	....	......
76b	" " lowest....	245 0	....	....	....	....	330	....	....	309	....	......
77a	First autumn frost—hoar.....	264.7	....	258	231	....	....	...	209	241	296	......
77b	" " hard	290.3	....	289	....	....	....	....	244	268	322	......
78a	First snow to fly in air..	293.4	....	298	....	....	....	....	305	259	310	......

* When becoming common.

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78b	First snow to whiten ground..	313.1	....	298	....	....	....	....	307	300	310	......
79a	Closing of lakes................	316 5	...	....	..	....	....	....	....	311	....	....
79b	" rivers................	351.3	....	345	344	....	....	....	....	312	....	......
81a	Wild ducks migrating, N......	76.3	80	....	....	....	....	....	97	82	....	......
81b	" " S......	295.1	....	....	....	....	....	....	305	300	...	......
82a	Wild geese " N......	76.1	73	60	62	98	....	....	96	80	....	......
82b	" " S	310.3	....	....	263	....	319	....	307	300	....	......
83	Melospiza fasciata, North ...	85.4	88	....	90	71	....	....	120	....	....	......
84	Turdus migratorius " ..	78.3	79	87	93	74	84	....	82	120	....	.....
85	Junco hiemalis "	79.1	87	....	92	86	67	....	88	....	....	......
86	Actitis macularia " ...	124.0	....	....	....	106	....	....	....	....	....	......
87	Sturnella magna "	107.0	....	...	....	95	..	...	98	....	....	......
88	Ceryle Alcyon " ...	121.3	115	...	...	140	...	....	....	....	....	......
89	Dendrœca coronata "	137.2	132	150	....	....	...	...	...	....	....	......
90	D. æstiva "	140.2	138	....	....	126	....	....	....	....	....	.....
91	Zonotrichia alba " ..	103.5	128	....	....	113	...	...	.	....	....	......
92	Trochilus colubris "	146.1	140	....	..	137	....	....	182	....	....	......
93	Tyrannus Carolinensis "	138.7	138	...	...	140	....	....	147	....	....	......
94	Dolychonyx oryzivorus "	132 9	138	....	....	133	....	.. .	....	....	....	......
95	Spinis tristis " ..	132.8	108	....	....	130	....	....	...	...	....	.. ...
96	Setophaga ruticilla "	127.7	142	....	..	130	....	....	....	....	....	......
97	Ampelis cedrorum "	138.0	9·	....	....	74	....	....	. ..	....	....	.....
98	Chordeiles Viginianus " ...	126.7	142	....	143	142	.	....	150	....	....	......
99	First piping of frogs	91.1	103	104	101	84	91	....	104	112	46	
100	First appearance of snakes ...	101.7	....	....	....	91	119	....	117	135	....	......

Ice-borne Sediments in Minas Basin, N. S.—By J. Austen Bancroft, *Acadia College, Wolfville.*

(Read before King's Co. Branch of N. S. I. S., 21st April, 1903.)

The power of running water to carry along mud, sand, gravel and fragments of rock to a considerable distance, is greatly increased in those countries where during some part of the year the frost is of sufficient intensity to form ice of considerable thickness.

During a winter of average severity, a person standing upon the government pier at Wolfville, King's County, N. S., watching an ebb tide, is impressed with the immense amount of ice carried down the Cornwallis River into Minas Basin. Within the ice, which is very muddy in general color, pebbles and fragments of rock may be seen entangled. This ice-borne detritus may be referred to at least three different sources:—

(i.) Ice forms along the banks of the rivers which flow into Minas Basin. During a slight thaw, small streamlets bear gravel and sand down upon its surface. Upon colder days, if there is not much snow on the ground, the wind sifts down its contribution of fine material upon the ice. With a following slightly higher tide, a layer of ice is formed upon the old surface, and a thin stratum of detritus is locked up and ready for later transportation. By the buoyant power of the water, assisted by sudden changes of temperature of the atmosphere, these projecting masses are broken off and are drifted away by the current. Each miniature iceberg thus formed, tears away some debris from the bank of the river.

(ii.) In some places, the shore-line of Minas Basin is marked by cliffs, which are exposed to wave action and the scour of tidal currents. For example, at Starr's Point and at Long Island, the land platform terminates in cliffs of a dull red sand-

stone of Triassic age. Its chief constituents are rounded grains of white to colorless quartz, decolorized and almost lustreless flakes of muscovite and biotite, and a few particles of decomposed feldspar, and the whole cemented together by calcite. The calcite fills the interstices of the rock, and forms a thin film about each individual grain of sand. The frozen interstitial water acts as a powerful force in the disintegration of this sandstone, cracking the calcite, and thus loosening the more durable grains of quartz and mica. Another instance may well be cited. Between Avonport and Hantsport, for the greater part of the distance, is a continuous cliff of purplish to black, finely laminated shale, with interspersed layers of sandstone and clay ironstone. In some places, the shale is capped by a thin layer of boulder clay. Water freezes between the laminæ of the shale, and breaks it up into thin scale-like fragments. Large cakes of ice are left by the receding tide beneath these cliffs, and on a sunny day, there is a continual shower of this frost-loosened detritus upon their surfaces. Sometimes landslides, on a small scale, of the overlying boulder clay pour down upon the ice a load of debris.

(iii.) The ebb tide leaves many cakes of ice stranded on the area which is left bare between high and low water. During the interval of time between ebb and flood tide, they are frozen to the surface of the ground ; but only to be floated again at high water. They then lift a thin layer of detritus from the land area to which they have been frozen. One ice crust was noticed floating about with a layer of sod, which, doubtless, had been in this manner removed from the surface of the marsh. Upon being floated, a layer of ice forms upon the lower surface of the ice and the debris is thus enclosed. If this action goes on for several days, it gives the ice a well stratified appearance.

During the second week in February, 1903, while studying at Acadia College, the writer, under the guidance of Professor Ernest Haycock, performed a series of experiments, in order to ascertain the amount of sediment carried by the ice in Minas Basin at that time. The winter was not very severe, and the

ice did not attain to the thickness which had characterized it during some previous years.

At the mouth of Mud Creek, the thickness of between fifty and sixty cakes of ice which had been left there by the outgoing tide was carefully measured. It was impossible to include in these measurements some of the thicker cakes of ice which were floating down the Cornwallis River. The average thickness, by this method, was found to be one and a half feet. This estimate was a very conservative one, since the thicker cakes of ice which are stranded, some even ten and twelve feet in thickness, seem to lodge upon the stretch of marsh laid bare upon the opposite side of the Cornwallis River. But in calculating the average, the cake of greatest thickness measured was seven feet thick, another was five feet thick, and the rest ranged from this down to three inches.

Much attention was given to the selection of those ice cakes which were carrying the average amount of sediment, and for this purpose many more cakes of ice were broken open and carefully inspected. Then thirty-four pounds of the ice containing an average quantity of detritus was melted and filtered upon large filter papers in the laboratory. The sand and mud collected on the filter paper was dried in an oven at a temperature of 90° C. The weight of the sediment found in this quantity of ice was found to be 1.1 pound. Upon examining portions of this material under the microscope, at least three distinct varieties of diatoms were noticed. From an admiralty chart, the length of the coast line of Minas Basin, was found to be about 120 miles, without taking into account the many small indentations and irregularities of the shore. The width of the tidal flats exposed at low water, from the same chart, was estimated to be about three-fourths of a mile. If these calculations are at all in error, it is due to the estimates taken not being large enough. The amount of ice in the Basin, at the time the experiment was performed, was such that when it was low water the tidal flats laid bare were covered with irregular ice masses, and much ice still remained floating.

The results of the complete experiment here appears in summary form, together with the conclusions derived from them :—

One square mile $= 5280 \times 5280 = 27,878,400$ sq. ft.

Average thickness of 59 cakes of ice $= 1\frac{1}{2}$ ft.

$\therefore$ Number of cubic feet of ice covering one square mile

$$= 27,878,400 \times 1\tfrac{1}{2} = 41,817,600 \text{ cubic ft.}$$

The weight of one cubic foot of ice of salt water on an average = 55lbs.

Now in 34 lbs. of ice, the weight of sediment found = 1.1 lb.

$\therefore$ In 55 " " " " " $= \dfrac{55 \times 1.1}{34}$

$= 1.779$ lb.

Hence the weight of sediment in ice covering an area of one square mile $= 41,817,760 \times 1.78 = 74,435,328$ lbs.

Length of coast line, Minas Basin (approximately) = 120 miles.

Average width of tidal flats $= \frac{3}{4}$ of a mile.

$\therefore$ Amount of surface (at the least) covered by ice

$$= 120 \times \tfrac{3}{4} = 90 \text{ sq. miles.}$$

$\therefore$ Weight of sediment borne by the ice covering this area

$$= 74,435,328 \times 90 = 6,699,179,520 \text{ lbs} = 3,349,590 \text{ tons.}$$

This result shows the transported material to be much more than might have been expected by the casual observer. But, after having performed the experiment, one has the feeling that the result obtained is far from being an exaggeration of what actually takes place. Where the stretch laid bare at low water is greater than at Wolfville, as in Cobequid Bay, the ice attains a much greater thickness. As might be expected, the amount of sediment carried by the ice varies with the severity of the winter. During what may be called a broken winter, several sets of ice may be formed,—a prolonged thaw nearly clearing the Basin of ice, only to be followed by a cold snap with a new ice crust.

The amount of sediment carried by this floating ice is greatly emphasized to one if he watches the melting of some of the ice clumps stranded upon the marsh by an exceptionally high tide. In one case, the layer of sediment left after the melting of such a stranded cake was six inches thick, and in the midst of the detritus was a boulder of trap rock which weighed over twenty pounds. Early in the spring, the marsh has the appearnce of being covered with ant hills, this effect being produced by the melting of these isolated ice cakes, and the deposition of their burden of debris. These scattered heaps of sediment do not seem to be easily levelled down by succeeding high tides. If by the continued formation of laminæ, deposited by the following high tides, they should be buried, it would seem as if they should be of some geological significance in the structure of the rock formed, at a later date, of these stratified marsh sediments. Possibly they would cause slight irregularities in the bedding, or give the rock a patched appearance. But this is largely conjecture.

This material deposited on the marshes in this way is caused by the standing of only a few stray ice cakes. A good deal of the floating ice is carried out into the Bay of Fundy. Much of it melts while floating in the waters of Minas Basin. Some of it melts while resting on the area left bare between high and low water. But wherever the melting takes place, it necessarily is accompanied by the deposition of the burden of detritus. The ice which floats about in Minas Basin during the winter, is thus seen to be a very important agent in the transference of mud and silt, abstracted from the land, to the sea bottom.

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"That authors' separate copies should not be distributed privately before the paper has been published in the regular manner.

"That it is desirable to express the subject of one's paper in its title, while keeping the title as concise as possible.

"That new species should be properly diagnosed and figured when possible.

"That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

"That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules of quotation, such as that recently adopted by the French Zoological Society."

THE

PROCEEDINGS AND TRANSACTIONS

OF THE

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CONTENTS.

TRANSACTIONS

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SESSION OF 1903-1904.

DISTRIBUTION OF BEDDED LEADS IN RELATION TO MINING POLICY.*—BY PROF. J. EDMUND WOODMAN, A. M., S. D., *School of Mining and Metallurgy, Dalhousie University, Halifax, N. S.*

(*Read 13th March, 1905.*†)

For purposes of study, the gold-bearing veins of the province may be roughly divided into two general classes, as regards their relation to the country rock—bedded leads, with their accompanying "angulars," and cross veins. This grouping is in part arbitrary, and real or apparent exceptions will occur to any one acquainted with more than a few of the gold districts. But it contains the essential elements of a true classification—the genetic principle. For from another point of view, the veins may be regarded as (1) those formed during the period of folding of the rocks, practically group one as given above; and (2) those formed subsequent to the folding, in cross fissures, joints, or faults, which would be group two.

The phrase "fissure vein" is to be avoided as far as possible in discussing either of the two classes. For, in the first place,

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we have yet to prove that any of them were formed after the manner of "true fissure veins"—that is, by wide-spread and deep-seated disruption of the rocks; and second, whatever some of the cross veins may be, others give distinct evidence of not occupying true fissures, but only shrinkage or torsion cracks due to local influences, and confined in strike definitely to a certain portion of the strata, dying out at either end as other strata are reached.

Third, in one sense all are fissure veins; that is, all were formed in pre-existing cavities or places of weakness.

The present paper undertakes only to consider some characteristics of the mineral deposits under group one. Certain of these have been emphasized, chiefly verbally, by Mr. E. R. Faribault, of the Geological Survey of Canada. It is difficult to speak too highly of Mr. Faribault's work, extending over a long term of years, and carried on patiently under most trying conditions, not the least of which has been a totally inadequate supply of funds.

Here the author begs indulgence for a momentary disgression. We are accustomed to grumble at the amount of study alloted to this province by the Geological Survey. Observation of work done in other parts of the Dominion convinces me that, in proportion to its apparent economic importance, Nova Scotia has received in the past, and is still accorded, more attention from the surveying staff than any other part of Canada. The Maritime Provinces are the only considerable division for which were early planned, and are now being executed, inch-to-mile geological sheets. Other regions have been mapped upon this scale, or even a larger one; but they are limited in extent, and generally embrace some distinct economic district, covered by a few map sheets. Except the parts now in progress of being surveyed, the areal geology of the province is mapped already, in a manner not perfect, it is true, but eminently satisfactory when the financial resources at command are considered. What the Survey does *not* do, is to attempt problem studies of geo-

logic or economic units. Its work is still too largely areal. Whenever the far-sighted policy is adopted of allowing it an annual appropriation more nearly commensurate with the needs of the Dominion, we, in common with others, will reap the benefit. Until then, with others, we must wait for the fulfilment of some of our ambitions for Nova Scotia. There is reason to believe that the maps we already possess are used with intelligence by a very small number of those interested in the mineral economics of the province.

Returning once more to the subject, we find that the problem permits of division into two parts—the relations of gold-bearing districts to each other, and the relations between the veins. Let us look at the distribution of bedded-lead gold districts as known at present. The discussion is here confined to that part of the province east of the great granite mass which, starting near Halifax, runs north and west to near Windsor: there meeting the Carboniferous rocks, and thus cutting off the eastern sedimentary part of the gold-bearing series completely from the western. The reasons for this delimitation of the subject are that the country is better known to most, the workings are more numerous, older and on a larger scale, hence give greater opportunity for study, and the rocks are much less influenced by granites.

In this region, which is approximately 200 miles east and west by 8 to 60 north and south, and embraces roughly 3,000 square miles, there are 26 well-marked anticlinal axes. Some of these extend many miles east and west, and a few are very local. In no way, however, do they run and die out *en echelon*, after the manner of axes in the Appalachians. From south to north, the anticlines on which gold districts lie, are (1) the Tangier fold, with Ecum Secum, Harrigan Cove and Tangier; (2) the Ecum Secum fold, a very local one, with a part of Ecum Secum; (3) the Lake Catcha-Salmon River fold, including Liscomb Mills, Salmon River, and Lake Catcha; (4) the Mooseland-Gegogan

fold, including Mooseland and Gegogan (Lawrencetown may be on a westward continuation); (5) the Wine Harbour fold, with Wine Harbour; (6) The Montague-Isaacs Harbour fold, with Montague, Gold Lake, Killag, Goldenville, and Isaacs Harbour; (7) the Moose River-Beaver Dam fold, with Beaver Dam, Upper Seal Harbour, Ragged Falls, and Moose River; (8) the Waverley-Fifteen Mile Stream fold, with Waverley at the west, running through Moose River, where it parts company with 7, to Fifteen Mile Stream; (9) The Caribou fold, containing Caribou, Cameron Dam, Crow's Nest, and Cochran Hill; (10) the Oldham fold, with Oldham; (11) the South Branch Musquodoboit fold, with an unnamed dome and Little Liscomb Lake mine; (12) the South Uniacke fold, with South Uniacke; and (13) the Mt. Uniacke fold, with Mt. Uniacke and Renfrew. Thus exactly half the anticlines have domes which are being worked, or which have been operated in the past.

It will be noted that there is a great variation, from one to five, in the number of known domes on individual anticlines. There is much difference, also, in the length of these anticlines —from 4.5 miles, in the local Ecum Secum axis, to about 105 miles in the Waverley-Moose River-Upper Seal Harbour fold. Further, the variation in interval between adjacent domes on the same axis is considerable. The two nearest together, unseparated by a fault, are Ecum Secum and Harrigan Cove, about 6 miles apart. This is the only instance of its kind, however, and Harrigan Cove has not a very good dome structure. The two adjacent districts farthest apart without an intervening fault, are Goldenville and Killag, about 34 miles distant. Mapping the domes upon one large sheet, so that the relations can be seen at a glance, it at first sight looks as though there were a tendency to an oblique northeast-southwest alignment of domes, the districts lying slightly farther east on each successive axis northward. Close inspection, however, shows that the tendency is really present in but two cases, and may well be accidental in these. To sum up, therefore, it appears that any

attempt to frame an exploration policy upon a supposed periodicity of situation of the domes is likely to end in failure.

In rebuttal, it must be said that we may not be acquainted with all the domes existing upon the various folds. This is undoubtedly true; yet it but emphasizes the inability of distribution to contribute prophetically to our knowledge. On the other hand, it enforces one aspect of the case which should appeal to moneyed men interested in the problem of developing our mineral industries. All the main anticlinal axes have been quite accurately mapped for the eastern half of the province by Mr. Faribault, and the sheets for the most part published. While small local folds may become known in the future, as the second one at Salmon River was discovered after operations at the Dufferin mine had proceeded far enough; and while some of these may prove economically important, yet it is improbable that there are many arches unnoted by Mr. Faribault's careful traverses. But one or two cases of gold-bearing bedded veins are so far known to exist in the trough of a syncline; and from the mechanics of the mountain building and attendant vein phenomena, it is not to be expected that such deposits will occur along the synclinal axes to any extent. So that, while our evidence upon this important point is either circumstantial or negative, it is probably safe to neglect these folds entirely in exploring for new deposits. Moreover, many of the synclinal axes outcrop in the overlying black slates, and therefore in rocks in which abundant gold-bearing leads would not be sought.

Again, while a few instances of isolated bedded veins are known in the transverse interval between an anticline and a syncline, and at a considerable distance from the axis of the former, they are rare; and they are not to be looked for to any considerable extent. It is along and close to the anticlinal axes that we know the deposits now worked, and that we should expect to find new ones; and further, it has been heretofore upon the bulged or domed parts that search has been made.

We know that in the existing districts there is a marked tendency for leads to narrow, and often to die out altogether, in passing from the plunging nose of the dome back to such distance that the axial line runs horizontally. Conversely, veins discovered so far back tend to become stronger toward and at the plunge. This principle is applicable to other than distinctly domed regions. An examination of any of the anticlines will show the inquirer that its axis does not run constantly horizontally, but undulates, plunging gently now east, now west, for miles at a stretch. In some instances, as the Upper Seal Harbour district, this long plunge is accompanied by belts of leads of proved worth ; but in most sections so far exploited, such leads lie where the plunge is accentuated, frequently in both directions, into a partial or complete dome. This does not prove, however, that leads are absent or even rare, in the long plunging stretches of which we have been speaking. It is most probably because of insufficient exploration that we know so few instances like the Upper Seal Harbour district. There are many stretches along all the anticlines known to have the long gentle plunge, which may be as likely to have paying belts as the few now worked. Further, the probability of finding distinct domes in parts where they are not now known is very great. Most of the present districts have been discovered by accident, perhaps all ; and none, so far as the author is aware, by deliberate, systematic prospecting, extending over a considerable stretch of country.

The point in all this is that here is the most promising field for exploration now open to us—the systematic testing of ground for miles along the plunging parts of anticlinal axes. In order to achieve success in this line, the prospecting must be undertaken progressively along the axes of the different anticlines, and must be careful and persistent. It will entail considerable expense, for means must be employed to reach bedrock wherever the structural conditions warrant ; but in the end it will undoubtedly repay the company bold enough to

undertake it. Indeed, there seems to be no other way to increase greatly the known area of productive territory.

Let us turn next to the second part of the problem—the relationships of the leads themselves. Just as among many geologists there has been an unfortunate tendency to correlate rock series with one another at a distance upon purely lithological resemblances, which in reality may be repeated time and again in the long history of the world, just so some economic men have thought it possible that bedded leads in different districts might be the same. And it would be a valuable piece of information if we could verify it. This view is an old one, earlier held more strongly than of late: and many of you disbelieve in it. Nevertheless, as questions and assertions on the point have arisen often, it is necessary to discuss it briefly. Resemblances in the quartz, or arrangement of the gold, or similarity in structural relations and intervals of the leads, have all been used as arguments in favor of their supposed continuity from one district to another. Perhaps the nearest points between which such correlation has been attempted are at Moose River, between the main settlement and the part called "West Mine." A careful survey has led the author to believe that the leads which plunge westward from the main settlement cannot possibly reappear at the western locality. But this is an isolated instance, although admittedly favorable to possible continuity.

In order to view the problem impartially, let us see what evidence can be had from several districts, individually and collectively. One of the most instructive is Caribou. Here are many bedded leads, lying in a zone just below the contact of the lower formation with the black slates, the so-called Halifax formation, above. This region is, in fact, an ellipse of the former completely surrounded by the latter, owing its existence to the fact that a large syncline of the slates has been puckered up by an anticline in the middle, the latter bringing older rocks to the surface. On the south and east, at distances of a

few miles, these old rocks again emerge from their cloak of of black slates, but we look in vain for any evidence of the bedded leads.

Perhaps an even more instructive case is presented by the interval between the settlement of Moose River on the south, and the contact of the quartzite or Goldenville formation with the black slates to the north, southwest of Caribou. At about the longitude of Moose River there are five anticlines, from the Carboniferous rocks of the Musquodoboit valley on the north to the ocean on the south, and excepting the Moose River and Caribou folds. These are the Gold Lake-Goldenville, Mooseland-Gegogan, Lake Catcha-Salmon River, Tangier-Harrigan Cove, and Southern anticlines. They are all south of Moose River. Every fold except the Southern bears two or more domes ; and three of the anticlines have Gold Lake, Mooseland and Tangier within a few miles east or west of the longitude of Moose River. Going from that district north to the contact, one traverses an open barren for the most part, on which outcrops are numerous. It is not likely that all the observers who have made the traverse have been deceived as to the structure, which appears to them to be that of a simple high north dip, with no folds. Nor are they likely to have overlooked entirely the large number of leads which should be there, if those of the three districts named are continuous for any distance. For a structural cross-section of the country shows that Moose River lies at nearly the lowest spot within the gold-bearing rocks laid open to observation by erosion ; while Caribou lies at the summit of the quartzites, and the three other districts are situated at structural horizons intermediate between these two. It is easy enough to compute the horizons—that is, where the leads *should* come—but they are not there. Instances might be multiplied, if necessary, all giving testimony to the same end. But it is enough to state that there appears to be conclusive evidence of a universal discontinuity of bedded leads, in all directions. Single veins have been followed for a few thousand

feet; but no lead has ever been traced out of its district to another one, either on the strike of the fold, or transverse to it.

Not only is this point clear, but another equally important one is proved by the same evidence—namely, the discontinuity of the horizons of slate belts which the veins accompany, and which are invariable characteristics of the domes. All who work the leads of the various districts know that they are not to be found, except in rare cases, away from slate belts; and "whin bound" leads are generally shunned. This holds true within the districts,—that is, on the known domes,—and equally outside these limits. No prospector wastes his time on country definitely known to be all whin. Now, not only do individual leads and groups of leads fail to "carry" over from one district to the next, but the slate belts in which they are enclosed fail to be continuous, either on the strike of the folds or transverse to it. More than that, the general horizons occupied by the domes, which elsewhere (The sediments of the Meguma series of Nova Scotia. *Amer. Geol., July, 1904; vol. xxxiv, pp. 13-34, esp. p. 17*) the author has called "horizons of most abundant slate," are localized in each and every case, confined to the particular dome on which we find them. This is proved, as in the case of the veins, by structural studies.

The great importance of recognition of this fact is apparent when it is seen that, according to this, each mining district has a definite limit, not only longitudinally east and west, and transversely north and south, but vertically downward. The deduction has a direct bearing upon the problem of deep mining. To put the matter more plainly, it will be necessary to look for a moment at the origin of the leads and their environing slates. The present distribution of the slate horizons shows that each group of slate belts, each district, is isolated: and that as far as known no two are to be correlated as of exactly the same age. That is, no two were simultaneously and continuously deposited. Between adjacent domes, in all directions the outcrops show prevailingly quartzite or whin. It appears,

therefore, that in a shallow sea of very ancient date, in which for the most part sandy sediment was deposited, irregularities of current action or of depth of water, allowed mud to accumulate to a greater extent in isolated spots, alternating with the sand. Later, when all the strata were folded into the well recognized east and west undulations, those parts which had the largest percentage of shaly sediment, being most plastic, folded most and stood up higher as domes. Obviously, they must be limited in all directions by sandy beds. The upper limit has been largely worn away near the axes. The lateral margins are visible today to anyone who searches for them. The lower limit would be reached somewhere, by boring.

Comparison has often been made between our auriferous beds and those of Bendigo—sometimes in a way unconsciously to mislead us as to the true conditions here. This is one of the cases in point. In Bendigo we have, not many isolated domes each with its own problems, but one great dome, with a single general pitch but with subordinate undulations. The dome is composite, made up of several minor folds; and these folds have irregular plunges and dips. The leads, there as here, lie in slate belts at or near the contact with sandstones; but there is a very constant relation between the lead and the sandstone, which is lacking here—namely, the foot-wall is always sandstone, the hanging wall invariably slate. The most marked dissimilarity between the two countries, however, is in the fact that at Bendigo the vertical as well as the lateral distribution of the gold districts is indefinite; and it is on just this point that we seem to be led astray. The large single dome of which we have spoken is, as was said, made up of a number of anticlines and synclines, striking north 16 degrees west, and sometimes continuous along the strike for many miles. There are 15 anticlines in about two miles of width, in the central part of the 140 square miles of productive territory, with an average transverse interval of 800 feet from crest to crest of the adjacent arches. The dips average 65 degrees; and while

the folds are not symmetrical, they are not highly overturned. The slates have a strong secondary cleavage dipping 65 degrees east, so that on one side of the fold it is parallel with the bedding, on the other transverse to its dip. This explains the "false saddles" so common there, which have no analogy in this country. Unlike the Nova Scotian cases, the dips are constant on either side, giving steep straight shanks and narrow sharp crests. This corresponds to what we have on only our narrowest folds. Conditions analogous to Goldenville, Mt. Uniacke, Renfrew, and many other districts do not exist in the Australian field. The leads of Bendigo often lie, too, in "inverted saddles." Indeed, the whole dynamic condition of origin was different there from that in our own series; and dynamic history in such cases has great influence upon profitable mining methods. The rocks there were evidently under much less weight of superincumbent material, or were more rapidly deformed when folding took place; for the sharp folds have allowed far more slipping of sandstone and slate past each other than with us. The result has been a series of saddles which individually are very thick on the crest, narrow rapidly downward, and die out for the most part within a few hundred feet.

On the average, one-half the saddles in Bendigo pay. Their vertical interval is very variable. In the New Chum and Victoria mine, 30 were passed in 2300 feet; while in "180" mine only five were cut in 2500 feet, two of them lean. In the Lazarus, 24 were met in 2400 feet, 13 gold-bearing. The continuity of single leads along the strike of the folds is unheard of elsewhere, one vein having been followed continuously for ten miles. The deepest mines, over 4000 feet, show ore unchanged in character. But it is to be emphasized that no mine has made a reputation on the basis of a single saddle. In every case vertical sinking has been resorted to, and one saddle after another uncovered, as was brought out in Mr. Faribault's first paper on deep mining. No single leg there has been found to extend very deep.

Aside from the necessity of sinking, the most important feature which can be used, not for comparison but for contrast with our local conditions, is the absence of any "horizon of most abundant slate"; and the consequent diffusion of the veins not only over a very great depth, but laterally over practically the whole extent of the great dome, about 140 square miles. We have exactly the opposite—much deeper legs to individual leads, but a very limited lateral and vertical extension to the domes or zones.

It has been computed by one student of the series that the difference in size between our folds and those of Bendigo is approximately as 20 to 1; and this has been used to prophesy the possible conditions underground as regards intervals between leads not now exposed at the surface, and length of leg on individual leads. Such statistics must be used with the greatest care, if at all; and in this case they are better discarded altogether. For if we push figures like these to their ultimate end, they act as boomerangs and discourage us completely. The fact is, the two districts are dissimilar in many essentials, while the superficial similarity of both containing bedded veins has blinded students to the relative value of the totally different factors entering into the equation of the two deposits. There are other regions of bedded veins in the world besides these, and altogether too much importance has been attached to the really accidental method of occurrence. To return to Bendigo, if our deposits are on a scale of 20, we may expect to go 50,000 feet vertically in some places to strike five leads, to use Lansell's "180" mine for comparison. Again, the 4,000 feet now reached by several mines represent 80,000 feet in which we may expect to find productive veins—which is too ridiculous for comment. No! The fact that there happens to be about that difference in the scale of construction of the folds in the two countries is interesting, but utterly worthless for prophetic purposes.

We have seen that our own veins are, to some considerable extent, localized within small domed districts; that these dis-

tricts show no evidence of repeating themselves at the proper geological horizons, but are distinct units ; and further, that they are definitely bounded on all sides. If one goes out from the center of such a dome, he will proceed from a part in which outcrops and underground cross-cuts show a definite alternation of slate and quartzite belts, rather suddenly into a region in which little if any slate is to be found. This is a typical condition. In just the same way, if one could see a sufficiently deep vertical section, he would find that thousands of feet of quartzite, with little or no slate, alternate with a few zones in which slate predominates ; and here would be found the bedded leads. The non-appearance of a bedded slate district on the next anticlines transversely north and south of that district, is itself proof of the presence of a very definite bottom to the slate part of each dome. Moreover, it is known that mud sediments are never deposited as enormously thick but closely localized patches ; but that there is roughly a maximum thickness for any given extent, and this is very small in proportion to the original lateral distribution of the deposit. Judging by these conditions in other parts of the world, the downward limit of the productive part of our domes should not be many thousands of feet below the surface in any case. In one district the author has a feeling, unsupported by other than circumstantial evidence, that this bottom lies practically at the surface for part of that field. Inasmuch, however, as no borings have been made or shafts sunk on the axis of any true dome to even a reasonable depth, all the evidence on this point that can be assembled with a view to helping us in the future, is external and circumstantial. The one established fact is that there will be somewhere a downward limit to the occurrence of new saddles, on each dome.

Thus far our study has been, perhaps, apparently pessimistic. It is intended that the paper as a whole shall be anything but that. It has been necessary to call attention to certain limitations of operations ; and to sundry facts, and the

correlations of these, in order to emphasize what the author believes to be policies which in the end will work injury to the gold mining industry. And chief of these is the vague idea that somewhere below we have a limitless body of ore, and can ultimately mine about as far as we like.—up, down, lengthwise, or sideways. No one has greater faith than the author in the ultimate success of the industry, when conducted on a large scale, by modern methods, and with business enterprise yet conservatism. The past year has been spoken of by some as especially disastrous in this field. If by this is meant a small output and a high gross cost merely, it is true. But this is a near-sighted view of the matter. The peculiar status of the industry today is due largely, although not entirely, to two causes. First, we are in a transition period between the day of one-man mines and small capital, and that of large capitalization and large scale operations. We have not yet accustomed ourselves to the change—nor, indeed, yet completed it. Some good properties are too highly capitalized, yet have too little paid in to meet ordinary current expenses of development and installation. With the large scale must come careful management, and among other things the blocking out and testing of several years' ore supply in advance. Very few mines indeed fulfill these conditions. Second, in several large properties which ordinarily can be depended upon to give a good record of themselves, the year has been spent in exploration, development work, or increase of surface plant. No wonder, then, that the output is small and the cost high.

As opposed to the negative side of the gold problem outlined earlier, must be presented a few facts which should tend to encourage the worker. First, while there is an undoubted downward limit to the zone of leads which could be cut by a shaft sunk on the apex of a dome, we have no evidence that in any given district it is within the range of moderately deep mining, or that many valuable saddles may not be cut by such a shaft. The experiment has never been seriously tried. Second,

while a very definite surface lateral extent is known for each true dome, there is many a district in which there are enough paying belts to keep one or a very few large plants for more years than any of us will see. Third, while there is a definite downward limit to each leg of a saddle, at which the vein dies out, it has yet to be shown that any one has reached that limit in a characteristic case. The only vein in this class which has been mined on the slope for a thousand feet of vertical depth shows unchanged character of ore at the bottom. Mr. Faribault's contention cannot be too strongly reiterated—that the depth of the vein left for our use depends entirely upon the proportion which erosion to an accidental present level has not removed; and that this will vary with each vein. Other things being equal, leads nearer the axis of a sharp fold should hold deeper than those farther away. Yet at Caribou we have a vein at a great distance from the axis, operated at over a thousand feet vertically. The advisability of following individual leads to a far greater depth than has been done must be emphasized to the utmost: and if the agitation for vertical sinking, good as it is, has detracted from the interest in this method of working, by so much it has done an injury to the industry.

What, then, are the constructive, practical applications which can be made from the facts and principles of the distribution of bedded leads? Without attempting to arrange them in any order of relative importance, some of them are as follows:

(1) There is a great field for exploration for new deposits. This should be systematic, along recognised anticlines for long distances. Special attention should be paid to structures similar to that at Upper Seal Harbour, which are common. The conditions of distribution there are in some ways nearer those of Bendigo on a large scale than anywhere else.

(2) There is room for far more exploring within single districts, but this is preferably done by underground cross-cuts.

(3) The present districts are even now held by too many owners for economical working. There are few, even of the

large fields, situated on regular domes and not too much affected by faults, which could not be worked as one property, from one, two or at the most three central shafts, far better than by the present methods.

(4) Much more attention should be paid to deep working on single leads or belts, on the slope. This is not to be taken as indicating hostility to the best large scale method—vertical sinking and cross-cutting ; but it is to bring out the fact that vertical sinking on an apex is not the only successful method, nor always the most desirable one.

(5) Boring and sinking on an apex should be used wherever the shape of the property and the structure warrant. It is undoubtedly the ideal way to initiate a large mining policy on a property capable of sustaining it. In this connection one thinks, of course, of the Government aid problem. It is to be said that conditions where the only case yet on record was attempted are not normal. The district, as has been mentioned earlier, is quite like Bendigo in certain ways ; but it is not a distinct dome, and this experiment should be tried upon a true dome before declaration is made upon its feasibility. There are few districts in which it would be advisable to make the trial for purely experimental purposes ; but there are some, and one of these should be chosen next. Those who realize the actual conditions in the field should have just as much faith as ever in the method, and in its ultimate success.

(6) Our ores are of so low grade on the average that large scale operations will be necessary, to make them pay for permanent investments. The industry is gradually being taken out of the realm of pure speculation, where it has been for long, and placed in that of legitimate business. To do this properly requires, for one thing, large reserves of proved ore, which an extremely small number of mines have at the present time.

Notes on Hydraulic Lime and Cement.—By Francis H. Mason, F. C. S., *Metallurgist, Halifax.*

(Communicated by Dr. Poole, 11th April, 1904.)

Setting of Hydraulic Lime and Cement.

It is generally accepted that the ingredients necessary to form hydraulic lime and cement are lime, silica, and alumina: while in all probability oxides of iron, and manganese and magnesia may, to a large extent, replace alumina without detrimental effect to the hydraulic properties of the lime or cement.

That it is not essential that the silica, oxide of iron and alumina shall be in chemical combination with the lime, is at once evident from the fact that the old Roman cement, described by Pliny, Vitruvius and others, consisted of a mixture of volcanic scoria and fat lime. Volcanic scoria is composed principally of silicates of peroxide of iron and alumina, with small quantities of magnesia, oxide of manganese and the alkalies. It is necessary that the scoria and the lime shall be in a fine state of division and in intimate contact with each other.

The initial setting of cement is undoubtedly due to hydration, while the hardening is, in all probability, due to chemical action.

Considerable attention has been given to the subject by a number of able chemists, which has resulted in a very great diversity of opinion The results of the researches of Le Chatelier are probably the most generally accepted.

His method of proceedure, namely that of examining thin plates of cement, at different stages of setting, under the microscope by the aid of polarized light, and then building up similar crystals synthetically to match, so to speak, does not carry with it that finality which analysis of those same crystals would have

done had it been possible to separate them mechanically for the purpose.

Le Chatelier claims that the setting of cement is due to the hydration of an aluminate of lime having the formula $4\ Ca\ O_3\ Al_2\ O_3$ which takes up 12 molecules of water; while the hydration of the silicate of lime $Ca\ O\ Si\ O_2$ which takes up 5 molecules of water, causes hardening.

The weakest point about La Chatelier's conclusions are that he finds the original cement contains the alumina in the form of a tri-calcic aluminate and the silica in the form of a tri-calcic ortho-silicate.

In order to get the tri-calcic aluminate, he has to first decompose the tri-calcic ortho-silicate, at the same time liberating free calcic hydrate, with which he forms his tetra-calcic aluminate thus:

$$2\ (Si\ O_2\ 3\ Ca\ O) + 14\ H_2\ O = 2\ Si\ O_2\ Ca\ O;\ 5\ H_2\ O + 4\ Ca\ H_2\ O_2;$$

then

$$3\ Ca\ O;\ Al_2\ O_3 + Ca\ H_2\ O_2 + 11\ H_2\ O = 4\ Ca\ O;\ Al_2\ O_3;\ 12\ H_2\ O.$$

Thus he has to bring about the reaction which he claims causes the hardening, before he can obtain the material causing the setting.

It has occurred to the writer that while the setting of limes and cements is evidently a process of hydration, the hardening may be due to the transferring of the silica from the alumina to the lime, leaving the alumina either in the free state or forming double silicates between it and the lime. In other words, that the function of the alumina in the setting of a lime or cement, is mainly that of a carrier of the silica to the lime. If such be the case, why should not other substances less basic than lime act equally well? The reply to this must take the form of another question; has it been proved that they do not?

The most likely sustances occurring in limestone to act as conveyors of silica to the lime, are oxide of iron and manganese.

and magnesia. It is well known that highly silicious magnesian limestones almost invariably possess hydraulic properties, and if we examine the analyses of natural cements and hydraulic limes, we shall find that while the percentage of alumina is erratic, with certain notable exceptions the percentage of oxide of iron, alumina and magnesia together are a much more constant quantity.

Take four analysis by Knauss given in Thorpe's "Dictionary of Applied Chemistry":—

Peroxide of iron	9.2	19.2	12.4	20.7	7.1	18.5	3.6	18.6
Alumina	7.3		4.6		9.8		5.6	
Magnesia	2.7		3.7		1.6		9.2	
Lime	48.2		46.1		49.2		47.1	

All these are reported to be good natural cements.

If, then, these substances only act as conveyors of silica to the lime, the question at once arises, would it not be possible to supply the silica in such a form, without the presence of these substances, that the lime would combine with it readily?

Landrin, in his researches, throws some light upon this point. He found that while pure lime intimately mixed with fine sand or powdered quartz possessed no hydraulic properties, it did set when mixed with precipitated gelatinous or dialized silica and in time attained a strength equal to the best Portland cement. He further found that 30 parts of silica would take up 38 parts of lime, corresponding to the formula $4\ CaO\ 3\ SiO_2$. In this we have a cement without alumina, oxide of iron or magnesia. If then, alumina, oxide of iron and magnesia act only as agents for holding the silica in a form in which it is readily attacked by the hydrate of lime, when that reaction has taken place they become inert and act as diluents and tend to weaken the final product, so that if it is possible to commercially prepare a cement free from these substances, pound for pound it should be of better quality than the highest grade Portland cement.

Unfortunately, where a quick-setting cement is demanded, alumina is necessary, for all these straight silica lime cements are slow setting under water, while they only attain their greatest strength if kept under water, owing to the lime being converted into carbonate by atmospheric carbonic acid when allowed to set in air.

The writer has repeated some of Landrin's experiments, using pure lime and native infusorial earth, after submitting the latter to gentle ignition, and obtained excellent products. Further, he finds that recently ignited infusorial earth slowly but surely takes up lime from lime-water when kept in a solution of the latter. The infusorial earth, which is perfectly friable after gentle ignition, becomes quite hard after an emersion in lime water for three months. The strength of the lime-water must be kept up during the experiment. 1.222 grammes of such earth in three months took up .549 grammes of lime.

Limestone from Barra Head, N. S.

The writer has for some time been experimenting with a limestone from Barra Head, near St. Peter's, Richmond Co., N. S. The first sample brought to him was composed of a single slab of highly carboniferous limestone, which, when burnt, gave the following analysis:—

Lime	70.10
Silica	16.30
Alumina	6·50
Peroxide of iron	1.36
Oxide of manganese	Traces
Magnesia	1.13
Soda and potash	.61
Sulphuric oxide	2.41

This lime set and hardened rapidly under water. The writer visited the property in the fall of 1902 and brought away two large samples of the quarried stone. Unfortunately other things intervened and only partial analyses were made

some time after the lime had been burnt and after it had taken up a certain amount of carbonic acid.

The following are the analyses :—

Lime	78.80	80.70
Silica	12.20	11.00
Alumina	1.74	1.76
Ferric oxide	1.56	1.14
Magnesia	.48	.53

Test pieces were made, and while they would not set under water, they set in two days in a covered jar over water and continued to harden under water. When thoroughly hard they were put out on the window sill of the laboratory and remained there the whole winter without in the slightest degree suffering from the continual freezing and thawing to which they were subjected. In the spring they had obtained a hardness almost equal to Portland cement similarly treated.

This was so encouraging that the writer interested other persons, and as soon as the hand diamond-drill was available four bore-holes were put down, three to a depth of 50 feet and one to 70 feet.

It was intended that eight holes should have been put down, but owing to the severity of the past winter and the difficulty of keeping the drill from freezing, only about half that amount of boring was accomplished.

The following are the analyses of average samples of each core after burning :—

	1.	2.	3.	4.
Silica	11.45	9.25	11.80	11.20
Alumina	3.57	3.25	3.19	3.11
Ferric oxide	1.48	1.14	1.28	1.29
Manganese oxides	0.08	0.10	0.63	0.70
Magnesia	0.25	0.25	0.43	0.52
Lime	81.25	83.55	79.60	80.00
Sulphuric oxide	0.44	0.42	1.61	1.71
Not determined and loss	1.58	2.04	1.42	1.47

The sulphur existed in the form of iron pyrites which, when burned in the oxidizing atmosphere of the muffle, was converted into sulphate of lime and peroxide of iron.

It will be noticed that the analyses show the deposit to be very homogeneous, and further, that the burnt stone has an analysis very similar to Portland cement with 50% of added lime.

Pats were made with varying proportions of quartz sand which set rapidly in a moist atmosphere and hardened under water.

Some of the lime was hydrated and mixed with twice its weight of quartz sand, allowed to set for two days in a moist atmosphere, then two months under water, then one month dry, when i gave a tensile breaking strength of 140 lbs. per cubic inch.

A briquette made from the samples taken of the quarried stone, burned, ground and mixed with twice its weight of gold ore tailings was placed, mould and all, immediately in water for two months, then placed on the window-sill for twelve months, and on breaking, it gave a tensile breaking strength of 354 lbs. per cubic inch.

Mr. Fennell, manager of the Wouldham Cement Co., West Thurrock, Essex, England, reported as follows on the adaptability of this limestone from Barra Head for the manufacture of Portland cement :

THE WOULDHAM CEMENT COMPANY, 1900, LIMITED,
LION WORKS,
Established 1855. WEST THURROCK, ESSEX.

29th Jan., 1904.

"I beg to state that I have thoroughly investigated the sample of stone recently sent me for examination, and report as to its suitability as a material from which to produce Portland cement.

"I have fortunately had considerable experience with the manufacture of high-class cement from materials practically

identical with that submitted, and may say that the sample ent shows this stone to be most admirably adapted for the purpose.

"It is practically identical in composition with the limestones from which some of the best cement in this country is produced, viz., the Lias beds occurring in Warwickshire and South Wales. The following is an analysis showing the average composition of the stone:—

Carbonate of lime	84.82	per cent.
Total loss on ignition	39.00	"
Matter soluble in hydrochloric acid	89.48	"
Matter insoluble in " "	10.52	"
Composition.		
Silica	9.94	"
Alumina	2.06	"
Ferric oxide	.89	"
Lime	47.14	"
Magnesia	.73	"
Sulphuric anhydride	Nil.	
Sulphur (as sulphides)	.34	"
Carbonic anhydride	38.57	"
Combined water	.09	"
Alkalies and loss	.24	"
	100.00	

"It will be noticed that the analysis, although more detailed shows the stone to be practically of the same composition as the English Lias stones above referred to, the composition of which is as follows:—

Moisture and organic matter	1.60	per cent.
Silica	11.15	"
Alumina	1.97	"
Ferric oxide	.36	"
Carbonate of lime	84.55	"
Loss	.37	
	100.00	

"It will be noted from the analysis that the stone contains 84.82 per cent. of lime, which is too high for a natural cement. It therefore becomes necessary to employ with it clay of a suitable character, and there should be. occurring between the layers of this stone, five or six clays of the requisite composition. This material, in common with the British Lias limestones, varies in composition in piece and piece, in this case the variation being, on the sample submitted, from 4 to 5 per cent. of carbonate of lime.

"In dealing with the production of cement from this material, therefore, it will be necessary to employ great care in the adjustment of the proportions of the stone and clay, which could only be done by the employment of a skilled chemist.

"The stone is readily pulverized, and it may be as well to point out that owing to the natural inter-mixture with it of a proportion of silicates of iron and alumina, or clay, it is not necessary to reduce it to nearly the same fineness as when dealing with Thames or Medway chalk, which is practically pure carbonate of lime.

"For the purpose of practically demonstrating the value of the stone as a material suitable for cement making, I have prepared some samples of cement from it, with the admixture of the necessary proportion of Medway clay. The following represents the composition of the clay used :—

Loss at red heat (organic)	5.39	per cent.
Silica	62.41	"
Alumina	18.09	"
Ferric oxide	10.35	"
Carbonate of lime	1.63	"
Alkalies	2.10	"
Loss	.03	"
	100.00	

"In the preparation of these samples, the clay was dried and ground with stone to such fineness as practically to leave no residue when sifted through a sieve of 10,000 mesh per square inch. The raw material thus obtained was mixed with water and allowed to dry into cakes which were burned to a clinker, coke being the fuel used in the burning. The clinker produced was then ground to the same fineness and the cement resulting gave the following analysis :—

Silica	22.80	per cent.
Insoluble residue	1.10	"
Ferric oxide } Alumina }	12.30	"
Lime	60.46	"
Magnesia	1.04	"
Sulphuric anhydride	1.30	"
Carbonic anhydride and water	.50	"
Alkalies and loss	.50	"
	100.00	

"An examination of this cement showed it to be a true Portland in every respect. It was burned to a s. g. of 3.175. Briquettes were moulded, to be broken at 2, 4 and 7 days old, and the following results were obtained. Unfortunately, I have not obtained the results for the 28 days :

2 days.	4 days.	7 days.	
185	345	450	lbs. per sq. inch
185	340	470	" "
210	410	485	" "

"It will be seen from the breaking strains obtained, that the cement is one which shows a steady growth in tensile strength, which is one of the most important and desirable features of a good Portland cement. The sample was also tested for soundness, and neither under the boiling water test or under the Le Châtelier test did it show the slightest sign of expansion or

blowing. The last named test is most searching in character, and is one which only a high class Portland cement would be capable of withstanding.

"Pats of the cement which were guaged and placed under cold water a few minutes after guaging, set hard and showed no sign of cracking or buckling.

"Accompanying this are samples of the ground limestone, ground clay, the raw material (admixture of stone and clay), cement clinker, and the finished cement. In addition are pats which have been subjected to the boiling water test, together with the broken briquettes and also the mould of cement which has been subjected to the Le Châtelier test.

"It may be borne in mind that in preparing small samples of cement, the maximum results are never realized, and cement made on a large scale with this material would give much higher results under test.

"In conclusion I beg to state that this limestone is one of the best possible materials from which to produce really high class Portland cement."

(Sgd.) WM. FENNELL.

I am inclined to think that there is a mistake in Mr. Fennell's analysis of the stone. It will be observed that no possible mixture of the limestone and clay of the analysis given can produce a cement of the composition given by his analysis.

There can, however, be no possible doubt that given a suitable clay for mixing, this limestone is admirably suited for the manufacture of Portland cement; and further, that the burnt stone by itself makes an excellent hydraulic lime.

The writer is now experimenting with two clays and a soft clay slate found in close proximity to the limestone for mixing purposes, and he hopes at a future date to prepare a paper on the cement industry at St. Peter's, Richmond County.

The following figures of the amount of cement made in and imported into Canada will be interesting. They are from the "*Canadian Mining Review*," for November, 1903:—

"During the year ending June 30th last (1903) the Canadian imports of Portland cement as given by the Department of Customs in the Trade and Navigation returns, amounted to 2,316,853 cwt., valued at $868,131, divided as follows:—

From Great Britain	516,796 cwt.	$187,572
" United States	610,445	305,775
" Belgium	814,252	244,633
" Other countries	375,360	130,151
Total	2,316,853 cwt.	$868,131

"This would amount, taking the weight of a barrel of foreign cement as 400 pounds, to an importation of 579,213 barrels of an average value of $1.50 per barrel; to this cost must be added a duty of 12½ cents per hundred pounds, amounting, at the average weight taken, to 50 cents a barrel. Now add to these importations the amount of the Canadian production and we have the following:—

	Bbls.	Value.
Imports of foreign cement	579,213	$1,157,737
Production of Canadian cement	594,594	1,028,618
Total	1,173,807	$2,186,355

Local Variations and Other Notes on Blue-Eyed Grass (*Sisyrinchium angustifolium*).—By J. H. Barbour, M. B., Capt. R. A. M. C., *Halifax*.

(*Read 11th January, 1904.*)

The following few notes on the above plant may be new to those interested in the flora of Nova Scotia and especially to those who have examined all our local species, I think that we should collect as much material as we can on variations, and particularly local variations, in order to see how far they arise and to what they point in the great scheme of adaptation to environment and the ultimate question of ascending or descending evolution.

So far, I know very little practically about Nova Scotian plants, as I have only had the past season in the country, but I did attempt to make a small collection, and while doing so was struck by the variation I saw in the flower referred to. So I made more extended observations on this species, which I think is one of your commonest flowers, just as common as the primsose (*Primula vulgaris*) is in England, on which for several years I made numerous observations on variation, the result of which I published in the form of notes each year.

Before proceeding further, let me give you a botanical description of the flower, which I dare say you know already, and then I will point out the variation observed in some one thousand specimens gathered this summer.

Nat. Ord., Iridaceæ. Perianth segments 6, blue, obovate, notched at the end and bristle-pointed from the notches. Stamen monodelphous. Stigmas thread-like, stem two-edged, leaves grass-like, plant slender, roots fibrous.

In one thousand specimens I noticed the following variations :—

60 specimens	possessed	only	6	leaves	in the	perianth.
20 "	"	"	5	"	"	"
10 "	"	"	3	"	"	"

The number of stamens corresponded to the number of divisions of perianth present.

The divisions of the perianth absent always belonged to the inner segments of the perianth.

As regards colour variation of perianth, first of all let me point out that the perianth is, as a rule, blue, and the outer leaves of it on the reverse sides are always lighter in colour than the reverse sides of the inner ones, the former being very light blue or almost white on the reverse side, while the latter on the same side retain their dark blue colour. Now, in the specimens examined, I found that the blue colour of the perianth is replaced by a distinct violet-purple in one hundred instances, and that this variation occurred not in fading flowers but in those in fresh, full bloom.

Another point I noticed, which is not a variation, but which I think may be found useful for diagnostic purposes, is the question of venation. Given only one segment of the perianth to look at, the outer leaves of the perianth are always marked by five distinct dark veins of blue, the inner only possesses three such lines.

The three outer segments of the perianth are always a millimetre or two broader than the inner three leaves, and the notches on the inner three leaves nearly always deeper than those on the outer three.

In about sixty specimens in a thousand you will find the bristle absent in the outer segment and replaced by a fringe.

I did not find one specimen I examined showing any trace of disease, and I only found one insect frequenting them, and that was a small black dipterous one.

These are all the remarks I have to make, except that these observations were made in Bedford and Sackville districts, Halifax County, N. S., and the variation occurred more in the open than in shade, and in low-lying places rather than higher.

Next year I hope to continue this series of observations on variations among plants here and extend them to other orders also.

THE SUNKEN LAND OF BUS (lat. 35 west, long. 53 north).—BY HENRY S. POOLE, D. SC., A. R. S. M., F. G. S., F. R. S. C., *Halifax.*

(Read 11th April, 1904.)

In latitude 53°, longitude 35°, the "Atlantic Ocean Pilot" notes a reported shoal, styling it "The Sunken Land of Bus," but gives no further information on the matter. It does not say whence the information, so laconically entered, was obtained. It does not tell us who Bus was, whether he was a Dutch navigator or related to the monk, Cæsar de Bus, of note in the sixteenth century. All the reference books to which I have access are silent on the subject. But, in that locality, recent investigations have proved the presence of shallower waters than those about it, if not of a shoal, in the usual acceptation of the term.

Through the kindness of Capt. DeCarteret, of the cable ship "Minia," I am able to present a record of soundings taken midway between Newfoundland and Ireland in June and July, 1903. The region is near, or possibly was even crossed, by the line of soundings obtained by Capt. McClintock for the first Atlantic cable in 1857.

The present series has disclosed the existence of a mountainous district in a locality where ocean's depths were assumed, from McClintock's infrequent soundings, to be those of a fairly level plateau with its shallowest waters 1550 fathoms.

The location of the region reviewed is accurately shown on the accompanying chart on a scale of six knots to five inches. The chart was kindly prepared by Mr. J. Adams, first officer of the S. S. "Minia."

As we are a maritime people, with a large proportion of our population directly interested in all that relates to the ocean at

our doors, we are desirous of recording any new discovery regarding its currents, its depths and shallows, and its inhabitants and their haunts.

A few years ago public interest was aroused in Atlantic soundings by the discovery of submarine peaks directly north of the Azores and near where, on old charts, the doubtful Chaucer shoal is marked. To this locality was given the name of the Faraday Hills. These hills were found to be surrounded on the east and west and to the north by waters of 2000 fathoms and over, thus giving to the mountain range an elevation of nearly 8000 feet above the general bottom of the ocean in that section of the Atlantic.

The soundings by the "Minia" last summer, recalled the discovery of the Faraday Hills, and in a popular way a reference was made to them in one of the monthly periodicals, but so far as I am aware, no accurate statement regarding them has as yet been published.

Memorandum of soundings on a line northward from the Azores:

	Latitude N.	Longitude W.
A depth of 770 fms. with deep water east and west	60°	33°
A doubtful shoal—The Sunken Land of Bus, Atlantic Ocean Pilot, p. 240..........	53°	35°
Hill region located 1903, by S. S. "Minia," depth 630 fms. &c....................	53° 22′	35° 12′
A doubtful shoal—Chaucer...................		
Faraday Hills, depth 714-730 fms. &c	49° 26′	28° 42
Corvo, an island of the Azores	40°	34°

In the foregoing table it will be noted that the shoaler waters between the 40th and 60th parallels of latitude lie in a due north and south course of the mean longitude of 32° west.

In addition to the accurate location of the soundings marked on the chart, information derived from other observations was also kindly supplied, and this may be thus summarized :—

Currents : An undercurrent constantly setting to the south-west at a rate of about half a mile an hour, was determined by the buoys which moved in that direction regardless of the surface flow and the wind.

Deposits : The sounding tube and the mushroom anchors brought up samples of various sorts of deposits, some that adhered to the anchor like mud, are so noted on the chart; others were of fine or coarse sand with, in some cases, small dark coloured stones. Then there was ooze and small shells.

Blue mud : This name was given to a deposit which, when freshly obtained, had a decided blue tint that it lost after exposure for some time in the air. The blue layer underlaid one of a yellowish cast and was alone obtained by the mushroom anchors. The sounding tubes did not penetrate deep enough to reach it. The tint doubtless was due to iron passing from the ferrous to the ferric oxide. In two localities the deposit was found to yield manganese, but in what form I am not able to report, as the samples were transmitted to London. The presence of the allied metals, iron and manganese, with a growing calcareous deposit, has its interest for students of the metalliferous zone of the Lower Carboniferous rocks of Nova Scotia, in which occur in irregular masses deposits of both iron and manganese.

Sand : This, so far as I am aware, was not the product of quartz, but of the breaking down of the siliceous and calcareous casings of organisms.

Pebbles : Of these a few were obtained in the sounding tube. Their composition has not been examined, but their surface is smooth to the touch and pitted by erosion. In addition to these were fragments as large as the tube would bring up, of volcanic glass showing the usual conchoidal fracture, and mixed with the ooze were small grains of volcanic ash.

Volcanoes: That the region is volcanic, the presence of obsidian leaves no doubt, and this conclusion is also suggested by the records of the grapnel work when the ship was drifting for the cable. Steep declivities were met with which required a rapid paying out or taking in the grapnel rope. So rough was the surface found to be in long. 34° 52′ that that neighborhood was abandoned and a fresh line of search was taken up. Notes of some of the rapid changes in depth are to be found on the chart, and the heights of the hills above the surrounding plain are stated as elevations of 100, 250, 500 and even 1200 feet.

Mr. Adams further informs us that while lowering the grapnal in one locality the tool struck an obstruction, hung for a moment, and then fell over 300 feet more. He concluded this was on the edge of a precipice and in consequence the assumed contours at this point are set very close together.

The following report by John S. Flett, D. Sc., F. R. S. E., on the rock specimens and some of the oozes collected by the S. S. "Minia" from the bed of the North Atlantic in 1903, is extracted from an article by Sir John Murray, and is inserted by the editor of the *Transactions*, although it appeared subsequently to the reading of the foregoing paper.

Specimen a.—S. S. "Minia," sounding 122, lat. 53° 12′ 15″ N., long. 53° 44′ W., 872 fathoms. Fine, buff-coloured, crystalline limestone, without traces of organic structures. It effervesces readily with cold dilute hydrochloric acid, and under the microscope consists of small crystals of calcite, forming a mosaic in which there are brown patches stained with limonite.

Specimen b.—S. S. "Minia," sounding 120, lat. 53° 8′ 45″ N., long. 35° 42′ W., 844 fathoms. Olivine basalt, fine grained, not distinctly porphyritic. It contains olivine, brownish augite, and lath-shaped plagioclase, with iron oxides, and the structure is of the "subophitic" type. Not vesicular. The olivine has weath-

ered to serpentine and limonite. There are a few small phenocrysts of felspar.

Specimen c.—S. S. "Minia," sounding 4, lat. 53° 20′ N., long. 34° 40′ W., 1397 fathoms. Porphyritic andesite or andesitic basalt. In this rock there are a few small phenocrysts of plagioclase felspar and brownish angite and magnetite. It contains no olivine, and is not vesicular. All the minerals are well preserved.

Specimen d.—S. S. "Minia," sounding 63, lat. 53° 14′ 30″ N., long. 35° 15′ W., 1440 fathoms. Perlitic tachylite, perfectly fresh, with a few skeleton crystals of olivine, and phenocrysts of plagioclase and greenish augite. The dark brown groundmass is very abundant, and is very free from microliths and spherulites; here and there it shows small rounded steam cavities.

Specimen 1.—S. S. "Faraday," station 62, lat. 50° 3′ N., long. 30° 46′ 45″ W., 1460 fathoms. Biotite gneiss, fine grained and somewhat granulitic in texture. It is very rich in microcline, but contains practically no muscovite; quartz appears in fine veins or strings, which are parallel to the foliation, as indicated by the biotite. Orthoclase is common, but soda-lime felspars are scarce. The biotite is brown, and is not abundant.

Specimen 2.—Same locality. Fine-grained granular basalt, very similar to specimen *b*, but without olivine. It contains many small phenocrysts of brownish augite.

Specimen 3.—Same locality. A sheared biotite granite or granite-gneiss, showing cataclastic structures throughout, and much decomposed. It evidently originally contained biotite, but this has been entirely replaced by epidote and chlorite.

Sounding 50.—Brown or buff-colored gritty, containing one pebble (a quarter of an inch in diameter) of black volcanic glass. Insoluble residue, 43·77 per cent. Minerals: quartz, (granitic, often brown stained, up to one millimetre in diameter,

mostly well-rounded, but the smaller fragments were often angular or subangular); orthoclase decomposed and rounded; microcline (rare); weathered oligoclase; also perfectly fresh sanidine, oligoclase, andesine and labradorite (in angular splinters and cleavage flakes). These last contained augite microliths and glass cavities. Brown volcanic glass, occasionally fluidal or finely vesicular, frequently perlitic, but not spherulitic, colourless, transparent pumice in fine shreds and splinters with concave outlines. Less common were magnetite in grains and small octahedra; pyroxene of two varieties, pale green and clear brown; chlorite; glauconite in rounded cryptocrystalline aggregates; olivine, perfectly fresh, in angular fragments; one small grain of pink garnet. Among the doubtful minerals were hypersthène, zircon, and epidote.

Sounding 58.—A tough, pale brown deposit, with many Foraminifera. Insoluble residue 54·14 per cent. Minerals: small rounded quartzes up to 0·3 millimetre in diameter, weathered orthoclase, sanidine, oligoclase, microcline, brown glass, shreds of pumice, hornblende, green and brown augite, magnetite.

Sounding 98.—Pale brown Globigerina ooze. Insoluble residue, 31·12 per cent. Minerals: quartz, mostly rounded up to 0·3 millimetre in diameter; orthoclase, microcline, sanidine, oligoclase, andesine, labradorite, fragments of colourless pumice and of brown glass, green hornblende, augite (brown and green), magnetite, olivine, epidote, glauconite; also a doubtful isotropic mineral.

Sounding 124.—Pale, creamy-white, coherent Globigerina ooze. Insoluble residue, 20·62 per cent. Recognizable mineral particles in this were very few, and formed not more than 2 or 3 per cent. of the sample. They were mostly brown and colourless volcanic glass, angular pieces of felspar, green augite. Quartz was either absent or very scarce.

THE SWIM BLADDER OF FISHES A DEGENERATE GLAND.—By PROFESSOR EDWARD E. PRINCE, F. R. S. Canada, *Dominion Commissioner of Fisheries and Directorof the Marine Biological Station of Canada, formerly Professor of Zoology in the Medical College of Glasgow Royal Infirmary.*

(*Read 9th February, 1903.*)

On examining, after appropriate dissection, the abdominal viscera of such a fish as a cod or herring, a prominent sac is seen occupying a considerable space underneath the vertebral column or rather underneath the kidneys and dorsal aorta (see Plate 20, fig. 1, *s. b.*). In the herring this sac communicates, as in most physostomous fishes, with the fore-portion of the alimentary canal, really in this case the stomach (Plate 20, fig. 3, *d.*) though as a rule with the œsophagus as in the carp (Plate 20, fig. 2,). The canal may be closed, and in all physoclistous fishes it wholly disappears. The perch (Plate 20, fig. 2), the haddock, (Plate 20, fig. 1), the cod, mackerel, &c., exhibit no duct. In some Teleosteans the swim-bladder is absent and in certain sharks and dog-fishes it is represented merely by a slight diverticulum in the dorsal wall of the gullet. The swim-bladder is, however, of general occurrence amongst osseous fishes, and its primitive character is proved by its mode of origin as a direct pocket or evagination from the pharynx, in the embryonic stages of fishes. The distinguished Scottish anatomist, Professor John Cleland, indeed, expressed the view that the parts of the digestive tract in fishes, so often difficult to determine, may be, in part at any rate, decided by the point at which the swim-bladder is pushed out. (See list of literature referred to, No. 5).

A glance at the extensive and scattered literature, dealing with this interesting organ, shows that very diverse views are

held concerning its nature and meaning. The famous Carl Gegenbaur has referred to the existing uncertainty as to the practical use of this structure (No. 8, p. 566), and one of the most recent contributors to the subject says (No. 24, p. 125) "even now there is much doubt as to the functions of the swim-bladder." From the days of Aristotle its use has been involved in obscurity; but the ancient father of comparative anatomy ventured on the theory that its purpose was to aid in the production of sound, and his successors have again and again revived the theory down to our own day. The Italian, Borelli, regarded it as hydrostatic and an aid to fish in floating (No. 2). A third interpretation is that the organ is respiratory, and in the Ganoids and Dipnoans, it is a complex, vascular, lung-like organ, with an undoubted pulmonary function; but it is by no means certain that the pharyngeal evagination or sac in those highly specialised lung-fishes is homologous with the swim-bladder, and I shall have occasion to point out that exception may be justifiably taken to such a view as that of Dr. A. S. Packard (No. 17, p. 444) who says, "the air-bladder being homologous with the lungs of higher vertebrates, the pneumatic duct is comparable with the trachea of birds and mammals," a view similar to that recently expressed by Professors Jordan and Evermann (No. 11, p. 11) that the swim-bladder is "a sac filled with air lying beneath the backbone of fishes and corresponding to the lungs of higher vertebrates." Professor Arthur Thomson, on the other hand, has given his opinion regarding the view just stated and says (No. 23, p. 397), "that the lungs and air-bladder are homologous is by no means certain; but the comparison is plausible." A further view interprets the swim-bladder as a barometer. Sagemahl (No. 21) regarded it as such, so that like an aneroid instrument, it informs the fish of changes in the atmospheric pressure affecting the surrounding water. Minor modifications of these views have been broached by other authorities; but a full examination of the facts seems to lend little support to any of them.

It is important at this point to notice the nature of the gaseous contents of the swim-bladder, so far as these have been ascertained. Most of the older authorities declared that it was filled with air, although Provencal and Humboldt, nearly a hundred years ago (it was in 1809), published an analysis which showed that, in some cases, oxygen filled the sac, while in other examples only 1% to 5% of the contents consisted of oxygen, and the greater portion was nitrogen. They thought that the oxygen increased with the depth of the fish's habitat, a view which later investigations have proved to be erroneous. In the fishes, for instance, brought up from the greatest depths of the sea, during the cruise of H. M. S. "Challenger," very little oxygen was found in the swim-bladder, while in specimens frequenting the surface waters that gas formed quite a considerable percentage. (No. 4, Vol. I, p. 226). Fish from a depth of 2875 fathoms showed not more than 4% to 5% of oxygen in the swim-bladder, but, at the surface, specimens of fish were found to have 34% or 35% of oxygen in the gaseous contents of the organ. Configliacchio and Biot discovered a large proportion of oxygen in specimens from fairly deep water, and the most recent authority on the subject (Professor R. W. Tower, of Brown University, U. S. A.), states that at a depth of from 35 to 70 fathoms the walls of the swim-bladder secrete oxygen very actively. The organ has nervous branches, gastric filaments, from the Vagus nerve, as well as a sympathetic supply, and, according to Bohr's experiments, division of the tenth nerve stops all secretion of gas, while section of the sympathetic nerve hastens the secretion of gas. Dr. Günther (No. 9, p. 142) has stated that, in fresh-water species, little oxygen gas as a rule is found, nitrogen prevailing, with just a trace of carbonic acid; but in sea-fishes the amount of oxygen is much larger. In a fresh-run salmon Dr. John Davy found 10% of oxygen, a trace of carbonic acid, and nearly 90% of nitrogen, an observation of a remarkable nature as the fish had only just left the sea, probably. All observations tend to show that there is no

foundation for an idea somewhat prevalent, that air or gas is forced from the gullet of the fish through the pneumatic duct into the swim-bladder. In those fish without a duct (Physoclisti) that is impossible, and in them as well as in Physostomes, the gas is evidently secreted by the vascular walls, the *retia mirabilia* of the organ. The varying proportions of the gaseous elements named, seem to show that no very important function is subserved by them. Nitrogen, which in the animal organism is excreted largely as urinary and fæcal waste, has been found to be absorbed under two peculiar conditions, viz.: when an animal is in a state of inanition, and when an animal changes its food and is accustoming its system to new forms of nutriment, a fact of singular interest, to which further allusion will be made on a subsequent page. The secretion, on the one hand, of oxygen or, on the other hand, of nitrogen may depend upon the special chemical conditions prevailing in the water being breathed by fish. Of the purely chemical causes which control the appearance and movements of fishes, one of the principal has been found to be the abundance or scarcity of oxygen mingled with the sea water. The absence of herrings from the Arctic seas has been frequently commented upon. The minute crustacean life which is so attractive, and so essential, it may be added, to the vast schools of herring, is extremely rich in the cold northern waters, yet herring do not appear to resort to those regions, whereas on both sides of the Atlantic the waters, adjacent to this continent and to the British Islands and the European continent, abound with herring. The Atlantic is more richly oxygenated than the Arctic seas, and this comparative lack of oxygen is no doubt the main factor in deterring the herring from migrating thither. Experiment has clearly demonstrated the dependence upon temperature of the absorbtive power of sea water. Barometric pressure too is important in determining the amount of atmospheric air absorbed, and as this air loses its oxygen far more rapidly than its nitrogen in its descending passage to deeper strata of water, these deeper

strata are of necessity imperfectly oxygenated, and unless disturbed by moving currents, unable to support the higher forms of animal life. As was shown by observations in the Swedish fisheries, the presence or absence of the usual schools of certain fish was almost solely influenced by the greater or less amount of water rich in oxygen pouring into the Baltic Sea from the open ocean. Active migratory fishes, such as mackerel and herring, must be largely controlled by these conditions, especially in waters more or less inclosed or separated from the open oceanic areas.

The line of thought here opened up is one of great practical as well as scientific importance; but I have treated elsewhere* of this and cognate matters affecting the environment of fishes and need not say more in this place. Nitrogen, as compared with oxygen, is of inferior moment in the vital processes, especially the respiratory processes, of the animal frame; but the amount of oxygen present in the swim-bladder, especially in fishes whose circumstances would seem to demand an ample supply, is too insignificant in quantity to be important in the oxidation phenomena going on in those organisms. The nature of the gases, which occupy the chamber of the swim-bladder would, indeed, seem to be wholly unimportant physiologically and dependent upon contingent circumstances. Fishes without a swim-bladder have, at any rate, no corresponding storage of gases.

The object of this paper is to show how little support prevailing theories (as to a hydrostatic, respiratory, barometric, accoustic, or other function) receive from the facts, and that whatever adaptations the swim-bladder may undergo, it is clearly not primarily in function either hydrostatic, accoustic, or sound-producing, respiratory, barometric, or for balancing or floating purposes simply. I would point out in the first place this most remarkable fact that, without exception, the anatomists who have treated of the functions of this organ, have ignored

*No. 18. p. xlviii.

all reference to its special features in the embryonic or larval stages of fishes. To understand the true nature and significance of any organ it is necessary to study its development, yet no authority, so far as I am aware has made reference to the remarkable features of the swim-bladder in the embryonic stages. Few have had the opportunity to study the larval development of fishes possessing this organ; and my own researches show, as might have been expected, how in the larval stages the swim-bladder reveals its primitive character, and that the variations in its form, position, connections, and minute structure, observed in adult fishes, are secondary, non-essential, and very seriously misleading. It is, however, on these secondary and misleading modifications that authorities have, almost without exception, based their views as to the nature and meaning of the swim-bladder in fishes. On very flimsy and inadequate evidence many eminent authorities have not hesitated to attribute extremely varied functions to this organ, and it is certainly remarkable that the most generally adopted views have the least support from observation. Young larval fishes in the sea swim in a reversed position, back downwards, and it might be supposed that the development of the swim-bladder aided them in "righting" themselves, and progressing dorsum uppermost, as they do later in life: but those without the organ adopt the latter position as readily at the accustomed stage as those possessing it. If it be hydrostatic it is difficult to see why fish specially needing buoyancy, like the surface frequenting sharks, the ponderous oceanic sunfishes (Molidæ), often more than a ton in weight*, the huge tunny, the mackerel, &c., should be destitute of it, while the shore-loving Gobiidæ, Scorpænidæ, Triglidæ, Gastrosteidæ, &c., have it well developed and of large size. The Sciænidæ, including no fish frequenting the deep waters of the open sea, have this organ in its most elaborate forms. It is large in the fresh-water whitefishes

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*This monstrous fish (*Mola*) as Packard says, (No. 17, p. 462), "is like others of the order, a surface swimmer."

(Coregoni), the grayling *(Thymallus)*, the shallow-water Gastrosteidæ and the river-ascending salmon, none of which seem to need any such supposed potent help to give them floating power. On the other hand, in the sea bass it is small, and in all the Serranidæ it is adherent to the abdominal walls. No fishes apparently need this organ less than the fresh-water suckers, yet without exception the Moxostomidæ and Catastomidæ, grovelling on the bottom of rivers and lakes, have a swim-bladder, consisting of two or three large sacs. To fish like the cod and certain deep-water lake whitefishes, it appears not only useless to aid them in rising in the water; but may even be fatal to them for when brought up from the bottom the expanded swim-bladder may seriously disorganize the fish and force the abdominal viscera out of the mouth. The halibut and flat-fishes can rise in the water, though these fish, so much in need of such an instrument of buoyancy, are not provided with it: neither are the Scombridæ (with such exceptions as *Scomber japonicus* as already pointed out) although to quote Mr. Boulenger (No. 1, p. 65) this family are "unceasingly active, their power of endurance in swimming being equal to the rapidity of their motions." The Cottidæ or Gurnard family have a well-developed swim-bladder yet, as the authority just quoted says, they are "bad swimmers and generally living at the bottom near the coasts" (No. 1, p. 62) —just as the Polynemidæ have a large swim-bladder, yet are purely littoral fishes, frequently hovering about the estuaries of rivers. The immortal Baron Cuvier, struck by the erratic occurrence of this supposed buoyant provision, admitted th t he saw no meaning in it and was unable to understand the want of so large an organ, not only in fishes which frequent the bottom, like skates and flat-fishes, but in many others which apparently, he said, were second to none in their rapidity and their facility of movement, such as the mackerel.

Its position immediately behind the cephalic or branchial section of the alimentary tract and its communication by an

open duct with the gullet, in almost all embryo fishes and in so many adult forms, with the frequent presence of a blood-vascular network, naturally suggested a respiratory use. It is not surprising that a respiratory function has been very commonly attributed to it. Many fishes are known to swallow air at times. The stone-loach *(Cobitis)* habitually passes air through its richly-vascular alimentary canal, as does the West Indian *Callichthys*. After oxygenating the blood circulating in the walls of the stomach and intestines, it escapes in bubbles posteriorly. The sea-raven *(Hemitripterus)* also distends its stomach with air, while carp and similar fish, in foul or muddy water, swallow air in quantities. Professor Alexander Agassiz pointed out that *Lepidosteus* when $\frac{3}{4}$ inch long, during the second or third week after hatching, rises to the surface of the water to swallow air, as it continues to do in adult life. Wilder observed the same habit in the bow-fin *(Amia)* of the Great Lakes, a regular exhalation and inhalation of air, after the manner of salamanders and tadpoles, which come to the surface of the water for air with increasing frequency as the larval branchiæ shrink and disappear. In certain Teleosteans, such as the Labyrinthici, where this resort to respiration by means of the walls of the alimentary tract might be readily anticipated, there is instead a special organ, which develops in an accessory branchiae cavity (Plate 23, fig. 7). Strangely enough, when these fish such as *Ophiocephalus* and *Anabas* are no longer in the water and are compelled to breathe air, the (closed) swim-bladder is not even then utilised ; but the vascular laminæ of the supra-branchial cavity are relied upon. Again, the Globe-fishes (*Gymnodontes*), which have the habit of distending their bodies by inflation so that the spines, studding their integument, project on all sides as a formidable armour, do not use the swim-bladder as one would expect ; but either " inflate a sub-œsophageal sac (which has a muscular sphincter, and extends beneath the skin of the abdomen) rendering themselves balloon-like," as Professor Macalister says (No. 14, p. 85), or fill the

stomach, or in other cases, the distensible gullet, with air for the same end. It is possible that these fishes having swallowed air for purposes of respiration, the habit has been turned to this other (defensive) purpose; but the important point to note is this that the swim-bladder has been utilised in these fishes neither for respiration, nor for defensive inflation and flotation. It is reasonable to suppose that in the assumption of a post-branchial respiratory habit the œsophagus would be utilised. That is the view of all anatomists; but, if an organ, so frequently present as the swim-bladder, be really respiratory, there must in addition to this very exceptional and abnormal habit among fishes of swallowing air, be developed an appropriate blood-circulation, *i. e.* venous or impure blood must be conveyed to the sac for the purpose of purification (oxygenation); but this is an arrangement not existing in any fishes excepting Ganoids and Dipnoi.

The features presented by the blood supply lend no support to the "respiratory" theory. The essential feature of respiration is the conveyance of impure or venous blood to a special organ for purification (oxygenation)*, the oxygenated blood passing away to the body, and leaving the carbonic acid to be got rid of in the readiest way; but the swim-bladder totally differs from such an arrangement. It is in fact supplied with arterial blood almost direct from the aorta or aortic arch. In such a form as the haddock (*Melanogrammus æglefinus*) the two epibranchial arteries unite, it is needless to say, to form the dorsal aorta, and on each side anterior to the union is given off a sub-clavian artery to the pectoral fins, and in front of the sub-clavian on the right side are given off two visceral arteries (the coeliac and the mesenteric) the latter going to the swim-bladder, but in the sharks it goes to the spleen, pancreas and intestine. From the swim-bladder the blood goes into the

*As Claus (Lehrb. d. Zool.) says "The blood must necessarily absorb oxygen and exhale carbonic acid. This interchange of gases effected between the blood and the medium in which the animal lives is the essential feature in respiration either in the atmosphere or in the water."

hepatic portal system. The oxygen which may fill, or nearly fill the swim-bladder cannot be regarded as destined for the purpose of charging with oxygen, or arterialising, the blood, for that is already arterial, and has just been charged with oxygen in the gills. Günther states (No. 9, p. 142) that the oxygen is really secreted by the surface of the swim-bladder, and there is every reason to hold that view; but such a process is therefore secretory, not respiratory in the accepted sense. Again, it must be noted that in such a fish as the haddock (Plate 20, fig. 1. *sb*) with a swim-bladder having extremely vascular walls, and a rich blood-supply, the organ is closed and the contained gas cannot pass out by a duct, whereas in the carp (Plate 20, fig. 4) with vascular fanlike tufts, in the pike *(Esox)* with small compact red bodies in which arterial and venous capillaries anastomose and in the sturgeon, salmon, herring, &c., though unprovided with these *retia mirabilia*, the swim-bladder is not closed, but has in most cases a very capacious opening through the dorsal wall of the œsophagus. The fact, on which Professor Rolleston laid stress (No. 19, p. 424), that in all species, when the branchiæ are in full activity, the swim-bladder is supplied with the purest arterial blood, lends little support to the supposition that it, in any way, subserves respiration. Of course in Dipnoans, like *Lepidosiren* and *Ceratodus*, the pulmonary function is undoubted; but the fact that the duct is ventral and not dorsal as in the Teleostei is of the highest importance. What is there to make improbable the suggestion that these so-called lungs are new structures correlated to the change in the circulation and the more highly differentiated condition of the heart. Wilder, it is true, states that in *Amia* and *Lepidosteus* he has found cases intermediate between the dorsal and ventral connection of the swim-bladder; but even if this variation of the duct be regarded as not wholly exceptional and abnormal, it cannot account for a dorsally-placed organ like the swim-bladder becoming a ventrally-placed lung, nor that a pulmonary artery, really a branch of the inferior aortic arch, carrying venous blood, should

supplant the mesenteric artery which supplies the organ in most fishes and that the blood leaving the swim-bladder should go direct to the heart rather than to the portal vein. In *Ceratodus* (a case of exceptional significance) the *arteria coeliaca* supplies the swim-bladder, and the duct of the swim-bladder exhibits a glottis.* True lungs, we know, arise as paired buds from the ventral surface of the œsophagus (Plate 21, fig. 3), and it is questionable to regard them as homologous with a dorsal diverticulum such as the swim-bladder of fishes (Plate 21, figs. 1 and 2). They may be, and probably are, structures arising *de novo*. May not this also be true of the lung of the Dipnoan fishes, as the swim-bladder and its connecting duct may disappear, and have done so completely in many fishes?

Closely connected with the supposed pulmonary character of the swim-bladder is the theory that it is an aid in sound-production. A hollow vesicle filled with gas may act as a resonator. We know that in certain fishes sounds are produced. Thus, as Dr. C. C. Abbott pointed out, the mud sunfish *(Acantharchus pomotis)* makes a grunting sound, the gizzard shad *(Dorosoma cepedianum)* a whirring sound: the chub-sucker *(Erimyzon sucetta)* utters a prolonged note due, it is said, to the air forcibly driven through the duct of the swim-bladder, the cat-fish *(Ameiurus)* hums softly, the "Drums," like *Aplodinotus grunniens*, make a grunting or croaking noise, and such species of the Sciaenidæ, as *Pogonias* make a loud drumming sound, especially loud in the male fish, while the eel *(Anguilla)* is declared to utter a musical note of a distinctly metallic character, These sounds, says Dr. S. A. Packard, are homologous with those of reptiles, birds, and mammals, being produced by the swim-bladder, which that authority holds to be the homologue of the lungs. Dr. W. R. Hamilton (9 a, p. 63) made however some experiments on the croaking of the fresh-water drum-fish, which is provided with

*Since this paper was written I find that Professor Albrecht of Brussels laid stress on the ventral connection of lungs and the dorsal position of the swim-bladder and its duct, and strongly opposed the homology of the swim-bladder and lungs.

large pharyngeal teeth. "While moving its grinders as I supposed the fish had done during life," said Dr. Hamilton, ". . . an exact imitation of the croaking of the perch was produced. I produced the sounds in a similar manner within the hearing of several Alleghany River raftsmen and Ohio River fishermen at intervals during the day on which I experimented, without allowing them to know how the noises were made, or that a perch was used for the purpose and they all declared it was an exact imitation of the croaking of the perch. . . . I cannot conceive of any way by which the sound could be produced by the air-bladder of the fish, as its physiological functions and anatomical structure do not indicate its use as a vocal organ." Dufosse (No. 7) attributed to the extrinsic muscles vibrations which produced sounds aided by the resonance of the swim-bladder; but in other cases he attributed the sound simply to gas violently driven through the pneumatic duct of the organ. The late Professor J. A. Ryder combatted this view which had been urged to account for the noise produced by *Aplodinotus*: "the usual view that the air is forced from one part of the air-bladder to another in the Sciaenoids seems to me inadequate in the absence of clearly worked out demonstrations. The group is physoclistous, or has the air-bladder entirely closed" (see note on p. 63, No. 9 a). Sorensen (No. 22) regards the organ as a resounding device, and thinks that it would have disappeared had it not so functioned. Yet the fact remains that most fishes are silent, and fish such as the cod and carp have never been credited with any gifts of voice, notwithstanding the size and high development in these fishes of the swim-bladder. The vastly greater number of fishes, which possess the swim-bladder, more or less highly developed, produce no sounds. They are silent and the organ occupying so large a space in the super-abdominal space is unutilised for that purpose. It is also remarkable in the extreme that some of the most active and buoyant fishes should be without this organ (*e. g.* the sharks and the family Scombridæ, or Mackerels, for

the most part). It is difficult to see why trout, carps, pike, sticklebacks, and sturgeon, frequenting shallows, where a hydrostatic organ is comparatively useless and unnecessary, are provided with it, while the Sand-launce (*Ammodytes*), the lump-fish (*Cyclopterus*), or the mackerel, should be without it. Its erratic occurrence shows how unessential it is to fishes now, however important it may primitively have been.

It is in the early condition, as seen in the embryonic and larval stages of fishes possessing this organ, that the swim-bladder is most interesting and suggestive. It has all the features characteristic of a large but simple gland. Krause distinguishes (No. 12, p. 206) four parts in a simple gland (1) the mouth, (2) the neck, (3) the body, (4) the cœcal extremity, and these may all be noted in the early swim-bladder, which is really a blind sac provided with a duct, and usually having an abundant blood-supply. Glands are always well supplied with blood, as their function is to secrete some characteristic substance from the blood passing through their vascular net-work. The swim-bladder arises, in all cases, as a dorsal bud or pocket of cells on the upper wall of the hind portion of the œsophagus. (Plate 1, figs. 21 and 2). At the earlier stages the gullet cannot be clearly marked off from the mesenteron or stomach. Thus, in a haddock, a few days before hatching an evagination from the dorsal side of the alimentary canal is observed projecting perpendicularly from the centre of the gullet. (Plate 21, fig. 4 *sb*). In the same microscopic section shown in the plate, a ventral diverticulum also appears, viz., the rudiment of the liver *(l)*. The section was in a slightly oblique transverse vertical plane, and therefore includes both organs. The lengthening of the alimentary canal, owing to the rapid growth of the young fish, soon more widely separates the swim-bladder and the liver, and, it may be pointed out, causes the straight canal to twist or curve to one (the left) side, and the balloon-shaped bladder curves over to the right, (Plate 21, fig. 5, *sb*). For some days

after hatching, the organ retains its simple cellular character, a single layer of large endodermal cells, not distinguishable from the cells forming the wall of the general alimentary tract. Soon a layer of flattened mesoderm cells (Plate 21, fig. 5, *mes*) creeps round and invests the organ, becoming later the connective tissue layer or tunica externa. The mesoderm cells rapidly become greatly thickened, as the larva grows, and the lining endoderm cells assume a swollen glandular character. Thus in *Trigla*, the gurnard, when $\frac{1}{4}$ in. (6 mm.) long, the cells are so enlarged as to crowd against each other, producing a very irregular internal lining, forming thick rugæ, the nuclei of the cells being, moreover, distally situated near the free ends of the cells, the contents of the cells being clear and non-staining (Plate 21, fig. 6). In a Gadoid, of the same length (6 mm.), probably a pollack or coal fish, a similar appearance is presented, but the nucleus of each swollen cell is central not distally excentric in position and the fine fibrous layer outside, really very much flattened and attenuated mesoderm cells, shows dense black pigment (Plate 21, fig. 7, *p.*) The presence of massed pigment cells, forming a dark patch in the region of the swim-bladder, is a marked feature in certain young gadoids (Plate 21, fig. 11).

In sections of a young Gadoid $\frac{5}{18}$ inch (6·5 mm.) long, probably a young cod a pollack I cannot now say which, for these allied species are practically identical in internal structure in larval life, the pigment layer is now more distinctly separated, and the nuclei in the large clear cells lining the swim-bladder are proximal and nearer to the thickened connective tissue layer. (Plate 21, fig. 8). In slightly older post-larval Gadoids say $\frac{3}{8}$ inch (9·2 mm.) long the cavity of the swim-bladder has greatly increased, the large mucus cells, with proximal nuclei are more regularly arranged (Plate 21, fig. 9), but a posterior portion of the organ is now marked off, with thin walls and showing no mucus-cell lining, indeed a dense thickened tubular section separates the anterior and posterior parts, in the wall of which

an artery now appears, while the two urinary ducts or ureters pass down each side of the swim-bladder posteriorly to the urinary vesicle behind. In a young *Callionymus* $\frac{1}{3}$ inch (7·8 mm.) long, the swim-bladder is capacious, and its walls thin, and membranous: but the floor is thick and its lining cells form dense rugæ not showing the clear mucoid character generally distinguishing the internal cells of the organ in many species. (Plate 21, fig. 10). The herring (*Clupea harengus*) of the same size, but no doubt very much older than Gobioids or Gadoids such as those just described, exhibits a very capacious thin-walled swim-bladder, the epithelial layer of cells being reduced in thickness. The larva was $\frac{1}{24}$ inch long (about 7 mm.) and the notochord was extremely large, while the alimentary canal was a narrow tube of very small capacity. Sections of a Gurnard (*Trigla*) $\frac{5}{12}$ in. (10 mm.) long, proved most interesting as the walls show no less than five distinct layers and an anterior portion with the usual mucus cell-lining was succeeded further back by a blastema of deeply stained tissue in which clear cells, possibly blood form-elements, are massed. Each rounded clear cell showed a definite deep-stained nucleus. This appearance suggests that a high vascularity is already characteristic of the interior of the swim-bladder at this early stage. The capacious front portion still, however, retains the glandular features, the large clear lining cells, each with a proximal nucleus, resting upon a dense nucleated stratum, outside being a complexly massed fibrous layer, external to which is a fourth stratum of flattened cells, three or four cells deep, the nuclei very marked, but much flattened, and outside all is a thick connective tissue layer (the tunica externa) composed of long interlaced fibres. Thus in the front part of the organ there are no less than five layers, (Plate 21, fig. 12, *a. b. c. d. e.*); but in the second portion the large-celled epithelium ceases, and the four outside layers described are present. The pigmented peritoneal membrane which encloses the organs of the abdominal cavity appears below the swim-bladder anteriorly; but further

back it ceases, and the organ lies directly upon the liver and alimentary canal. The peritoneum never indeed surrounds the swim-bladder, at any time during the life of the fish. If an embryologist, or an anatomist, were for the first time confronted with an organ having the characteristics of the swim-bladder in fishes during their early larval life, he would, without hesitation, pronounce it a gland. The salivary glands, for instance, in the human subject develop in the six-week embryo as a protrusion of the deeper epithelial layer of the mucous coat of the oral cavity becoming hollow after its protrusion and developing follicles, in which occur large transparent cells, each with an excentric nucleus stained by carmine while the surrounding mass of cell-substance remains clear and unstained. Other cells, called " peripheric," occur in the follicles which are not mucous, but albuminous and stain completely. Dr. W. B. Carpenter said (No. 3, p. 132), " It is believed that the albuminous cells during the period of rest of the gland gradually become metamorphosed and develop into the mucin-holding cells." I do not wish to attach too much importance to the circumstance; but in one specimen of a cod, $11\frac{1}{2}$ mm. ($\frac{1}{24}$ inch) long, the anterior portion of the swim-bladder was lined, not by large clear cells, with a nucleus alone staining by carmine; but a dense deep staining mass of reduced agglomerated cells as though the large cells had become metamorpho ed into something like the small dark granular cells which fill the salivary acinus during the period of active secretion. The swim-bladder, in its earliest condition, may be compared to a large gland, not compound and complexly developed like the liver; but a simple sac or huge follicle, its fundus or distal region lined by large epithelial cells, and leading into a non-glandular second portion, which may indeed be regarded as having subserved a storage function like the gall-bladder in that great secreting gland, the liver, and finally leading by a duct to the opening into the gullet which may or may not have a sphincter muscle. This duct may in a large number of species

of fish wholly degenerate later. In the pike-perch or pickerel (*Stizostedion vitreum*) exhibiting when adult a ductless swim-bladder, still possesses the duct when the fish is 6 or 8 inches long, and it is even then hollow for a great part of its length. In the familiar stickleback (*Gastrosteus*) the duct persists and remains open for a comparatively long time, although in the adult stage it disappears.

I have made reference to the salivary glands in speaking of the glandular character suggested by the early features of of the swim-bladder. Fishes exhibit no salivary structures whatever, unless the lingual follicles in the Lamprey be of that nature; but if, as I think it is clear, or at any rate not improbable, that the swim-bladder was primitively a gland, which has lost the glandular function, then its function cannot have been remotely unlike a secreting organ, active in providing a medium for lubricating food in the anterior portion of the alimentary canal. Such lubrication of the food became of course unnecessary in fishes, such as the Sharks which practically possess no oesophagus for the huge stomach opens directly to the mouth and the food is gulped at once into that capacious digestive chamber, the mouth with its array of teeth and the wide gullet have chiefly the task of preventing the escape of the seized prey. There are many glands in Vertebrates now without use or whose use is difficult to understand yet they persist. The small finger-like pocket in the rectum of Sharks (the rectal gland) is not understood. In the Chimaeræ or Rabbit-fishes, closely allied to the sharks, it has degenerated, and forms merely a slight projection on the intestinal wall. A still more remarkable case is the thyroid gland in man, the origin of which must be sought not in the fishes, but in the still lower and more primitive Urochordata or Tunicates. The hypobranchial groove or endostyle of the Ascidians, whose cellular ridge, on the internal ventral wall of the pharynx, secretes a mucus which entangling the particles of food, is passed, by the dorsal lamina, to the digestive tract. The

endostyle has an alimentary function and is found in the Enteropneusta (*Balanoglossus*). It is represented in the larval lamprey, and in Amphioxus, and, indeed, in some stages, in all Craniota. As the tongue, in the higher forms, becomes more important and grows, the endostyle is reduced and assumes the character of a canal closed off from the mouth cavity. It persists as the thyroid gland in the highest Vertebrates, indeed in man himself, but its original physiological relations and purposes are lost, and it becomes wholly disconnected with the digestive canal. As Dr. T. M. Studler (No. 20) has shown the right thyroid rudiment, in a $5\frac{1}{3}$ weeks embrys (*Homo*), is still connected with the pharynx ; but its fellow on the left is further advanced and has lost its primitive connection.*

The swim-bladder is an outgrowth of the stomodaeum or rather the posterior buccal portion of the alimentary canal, the part which in a great majority of animals is very well provided with glands. If it be, as I have ventured to suggest, a degenerate gland, its anterior position is explained, much as its connection may shift later in obedience to physiological and anatomical exigencies, ceasing, indeed, to have any oesophageal connection whatever in the physoclistous fishes. In such a fish as the herring, it does not communicate with the pharynx, but with the gizzard-like crop, while its posterior attenuated continuation opens by a duct on the left side of the anus(Plate I, fig. 3, x.) Its persistence in so many fishes, though it has disappeared in so many, may be explained by its deep position. An organ removed from the external modifying conditions, which may not not merely reduce but obliterate useless organs comparatively rapidly, do not affect so potently a deeply-seated useless organ and the tendency is for such an organ not to disappear but to be modified for a variety of functions. It is easy to understand, therefore, not only its persistence, but its actual increase in size and complexity in spite of its increasingly unimportant and

*Other glands might be referred to, such as the thymus which is largest in man two years after birth and diminishes with age, while the thyroid, which is largest at birth, may wholly disappear in the adult.

non-essential character. Its form and relations may become most surprising in character. Its minute structure may show the most perplexing variation. The delicate membrane which forms the silvery tubular sac in the herring (*Clupea*) Plate 20, fig. 3, *sb.*, or the capacious ovate organ attached to the inner surface of the dorso-lateral body-wall in *Perca*, Plate 20, fig. 3, *sb.*, is in great contrast to the thick massive-walled swim-bladder of the sturgeon (*Sturio*) (Plate 23, figs. 1, and 2), or the spongy, complexly meshed and vascular organ seen in the Bowfin (*Amia calva*). Special muscles occur in the walls. They are usually striped *i. e.* voluntary, and under the control of the fish ; but the duct possesses unstriped muscle, excepting in the rare cases where a sphincter muscle is present for closing and opening the entrance to the duct. Humboldt thought that the muscles of the swim-bladder effected its compression, and aided in the descent or ascent of fishes in the water, an idea which M. Delaroche (No. 6) admitted, might be possible though his own researches rather pointed, not to effecting by the swim-bladder such a change in the specific gravity of the fish as compared with the surrounding water, but rather to keeping it at the same specific gravity as the watery environment and presenting the fish rising or sinking. M. Moreau, in his later researches (No. 16) confirms Delaroche's view and adds that the equilibration is due to the external pressure of the water upon the body walls, and he emphatically contradicts Humboldt's idea and asserts that the muscles on the walls of the swim-bladder are not used to regulate or alter the volume of that organ.

In general the walls of the swim-bladder exhibit four layers in the adult fish viz.: (1) a tesselated lining epithelium ; (2) an inner fibrous layer, often silvery in appearance, due to wavy fibres or to bright crystalline rods ; (3) an outer thick fibrous layer, yielding isinglass, and especially dense in *Sturio* ; (4) a very delicate muscular stratum, which may be so arranged as, it is claimed, to compress and drive the

contents of the posterior chamber into the anterior chamber of the swim-bladder. The internal vascular structures are very simple and confined to one portion of the swim-bladder as in the conger, (Plate 22, fig. 1), which exhibits two red rounded vascular bodies (*a.a.*) situated near to the entrance of the pneumatic duct, or the blood-vascular network is spread over a large portion of the internal surface forming, as in the haddock, a dense reticulum of blood-vessels, or again these *retia mirabilia* may be wholly absent. In size the swim-bladder varies exceedingly, it may be small as in many of the herring family but simple in form, (Plate 20, fig. 3, *sb.*) It may as in the common perch (*Perca flavescens*) be still simple but of larger capacity as compared with the size of the fish, (Plate 20, fig. 2, *sb.*) Thus in a 10 inch perch the swim-bladder is no less than 4 inches long and nearly an inch in diameter, while in a perch 7½ inches long the organ is 3 inches in length. Its volume is not more variable than its shape and relations to other organs in the fish possessing it. In very young post-larval fishes it forms a prominent feature, glistening like a silvery gaseous bubble of elongated shape through the translucent body (see figure of Cunner ½ inch long, Plate 21, fig. 13, and Plate 23, figs. 3. 4, 5, 6.) Instead of the simple ovate sac of the Perch and Cunner, it may become extremely elongated as in the Herring sending forward a pair of delicate ducts, which end in two swollen sacs in the skull, close to the ear, one on each side, or as in the Haddock or Cod ceasing all connection with the alimentary canal, the capacious sac may continue forwards as two solid vermiform cornua terminating near the ears, (Plate 20, fig. 1, *corn.*) In the Carp the pneumatic duct not only persists but the anterior sac of the two-chambered swim-bladder may directly connect with the vestibular sac of the ear by ligaments and a chain of three bones, (Plate 20, fig. 4, *i. k. l.*), really costal modifications, the last and longest being attached to the swim-bladder, (*sb.*). In the Siluroids the relations of the two organs are far more complex, for the anterior vertebræ may coalesce

and their lateral processes expand as a roof or bony shield over the anterior portion of the swim-bladder. Even the South American species *Hypophthalmus*, so universally regarded by anatomists as lacking the swim-bladder, has been proved by Professor Ramsay Wright to be no exception, the rudimentary swim-bladder being present, completely paired (really two separated vesicles), and partly enclosed in the vertebral body and the walls of the neural canals and in the ossified *tunica externa* (No. 26, p. 116), while it has connection with the auditory organ by a chain of ossicles much reduced, but as Dr. Wright points out, "after precisely the same plan as in the other Siluroids," (loc. cit. p. 108). On each side a so-called malleus connects with a stapes, by an incus, with the lateral wall of the atrium sinûs imparis, the bones named being modified portions respectively of the first, third and second vertebræ. The stone-loach (*Cobitis*) like its congeners generally (the Acanthopsidæ) exhibits a bony case on each side of the most anterior vertebræ, in which the two globular chambers of the swim-bladder are enclosed side by side.* The two protecting bullæ are expansions of the transverse processes of the second and third vertebræ, (Plate 20, fig. 5, *bb.*), and hide from view the chain of three ossicles. The tropical American and African Characinidæ have a swim-bladder divided into two parts connecting by a chain of ossicles, with the auditory organs as in the Carps and Siluroids. The Cyprinodonts, diminutive carp-like fishes very abundant in Canada, have, however, no such auditory connection by a series of ossicles, while one Central American species, *Rivulus*, has been found to be destitute of the swim-bladder altogether. The carps (*Cyprinidæ*) and the pikes (*Esocidæ*), and other families like the oceanic Halisauroidei, possess a simple swim-bladder, often a two-chambered sac with thin membranous walls, opening into the gullet by a tube, while

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*The swim-bladder in *Heterobranchus* and *Malapterurus* exhibits the two rounded sacs. (Plate IV, figs. 8, 9.).

in the physoclistous perches, of which *Perca flavescens* is a familiar example, and in the Squamipinnes (the brilliantly tinted chaetodons, &c.), it is likewise simple in form and structure often showing a trace of anterior bifidity, (Plate 20, fig. 2). It may still preserve its simple sac-like form, but be paired as in *Gymnotus*, the electric eel, or completely bifurcate as in the physoclistous Brotulidæ and Acanthuridæ. In the simple swim-bladder of the cod or haddock, (Plate 20, fig. 1.), a number of lateral processes fringe the upper margin of the organ on each side, corresponding wlth intervertebral spaces, while a pair of cyclindrical solid prolongations pass forward to the auditory region ; but in the Sciaenidæ, excepting *Larimus*, which has a simple sac, the fringe of lateral processes becomes elaborate. In *Pogonias*, the Drum-fish, they are broad, leaf-like, and laterally unite on each side in a tube which opens into the posterior end of the organ, (Plate 22, fig. 4.). In *Johnius* they form a complicated fringe of ramose pectinate processes and in the example of a Sciænid swim-bladder figured by Dr. Günther over a hundred of these pectinate, much subdivided, processes occur, (Plate 22, fig. 3.). Another type of swim-bladder is represented in this family by such a form as that assumed in *Corvina*, (Plate 22, fig. 2.) There seems, indeed, to be no limit to the variation in the details of this organ in various groups. The internal cellular or sacculated character found in the swim-bladder of the *Notopteridæ* seems to presage the elaborate lung-like structure in some Ganoids and in the Dipnoans ; but I have stated the grounds for not regarding this latter organ as the homologue of the swim-bladder. It may be, and for the reasons set forth in this paper I do not doubt that it is the case, that the ventral air-bladder or subœsophageal sac even in Teleosteans such as the Gymnodonta, extending beneath the skin of the abdomen and opening by a duct, with a sphincter muscle, into the gullet, is a new structure and not homologous with the dorsally connected swim-bladder of Teleostei generally. If the modern sharks have lost the swim-bladder, or show

merely a rudimentary trace of it in some species, and if so many Teleosteans have become bereft of this organ and now show no traces of ever having possessed it, I see no improbability in the view I now urge that the Ganoids and Dipnoans, possessing a ventrally-placed lung-like sac, have acquired it as a new development, a new organ, and that it, not the dorsally connected swim-bladder of other fishes, is the prototype and homologue of the lungs of higher Vertebrates. This organ, arising *de novo* as it seems to me, was provided with a vascular supply (a venous connection) quite different from that, an essentially arterial one, which is exhibited by the swim-bladder in most fishes.

Regarding, then, the swim-bladder as primitively a gland whose original use is gone, like so many disused organs in the animal frame, can it be said that it has any use now, or have the various functions attributed to it, hydrostatic, accoustic, barometric, respiratory, &c., little or no basis in fact? I have already pointed out that nitrogen has been found by physiologists associated in the living organism with a state of dormancy and inanition, and with altered alimentation, *i. e.*, a change in the nature of the food. Both these states are characteristic features in the life of fishes. Whether fish sleep or not is a matter of controversy; but that they may pass into a state of dormancy, a condition of inanition, is well-known, while the changes in the diet of fishes, at various ages in the young, and at particular seasons in the adult fish, are recognized by all authorities. The storage of nitrogen, secreted from the blood circulating in the vascular network of the swim-bladder, may be associated with either or both of these states, a state of dormancy or inanition, or a state induced by a marked change in the character of the nutriment or food consumed. In venturing to interpret the swim-bladder as a glandular structure, whose original function has gone, I have done so because that interpretation best accords with its character in the embryonic and larval condition of the fishes possessing it. To all the

other various interpretations which have been put forth, serious, and to my mind, fatal objections exist.

In conclusion I may sum up the points on which I would lay emphasis. The swim-bladder, in its earliest condition in the embryo and the post-larval stages, exhibits the characteristic features of a secreting gland, opening by a duct into the anterior portion of the alimentary canal. It arises as a protrusion from the digestive tract like the hepatic evagination which becomes the liver, but this huge gland (the liver) with its capacious bile-duct is on the ventral side whereas the swim-bladder is on the dorsal side of the tract. The degeneration and disappearance of the swim-bladder in so many fishes proves that it is clearly not essential for flotation. Some of the most active pelagic species like the Sharks, Sun-fishes, Mackerels and others are without it, while fishes like the Pleuronectidæ and other bottom-frequenting species likewise lack that organ, though apparently so much in need of a hydrostatic device to facilitate their ascent or descent in the water. Inshore littoral fishes and shallow-water species (freshwater and marine) are almost without exception provided with it, though so little needed, in their case, for floating purposes. If its hydrostatic utility be questionable, it is clearly not for respiratory purposes, as in most fishes venous blood is not conveyed to it; but blood which has immediately before been arterialised and fully purified in the gills. Its dorsal connection and position superior to the alimentary canal indicates that it is not the homologue of the pulmonary organs with their duct opening on the lower side of the œsophagus. Professor Arthur Thomson pertinently observes, (No. 23, p. 391), " The air-bladder lies dorsally and is almost always single: the lungs lie ventrally, and are double, though connected by the gullet by a single tube. It is not certain that these outgrowths are homologous, though the air-bladder of Dipnoi acquires the functions of a lung." That the swim-bladder aids in audition, and in sound-production or voice, is suggested by the chain of ossicles (the complex Weberian apparatus) in such fishes as the

Siluroids, and Carps; but it has never been demonstrated by experiment that these fishes have hearing or sound-producing powers superior to other fishes not possessed of this apparatus. The sturgeon and cod, though provided with a large swim-bladder are silent. If the swim-bladder, again, be barometric why is it denied to so many fishes to which a knowledge is necessary of the variations in pressure of their atmospheric and aqueous surroundings? The presence of the organ in different families of fishes, as Gegenbaur points out, indicates some important purpose, though it may be said that the persistence of numerous obsolete and disused organs is most remarkable, the thymus gland being a familiar example. An external or exposed organ, which becomes useless may disappear rapidly like the pectoral fin of the lower side in the variegated sole (*Solea variegata*, Donov.), but an internal deep-seated structure is more likely to remain and become modified rather than disappear. Such transformation and change of function the swim-bladder of fishes has unquestionally undergone.

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LIST OF REFERENCE LETTERS IN THE PLATES.

a. anus
bl. gall-bladder.
b. b. bony expansions of vertebral processes.
corn. cornua or anterior processes of swim-bladder.
d. duct of swim-bladder.
do. opening of do do in œsophagus.
epith. large epithelial cells lining developing swim-bladder.
go. genital opening.
ht. heart.
l. k. l. chain of ossicles from ear to swim-bladder.
int. intestine.
k. kidney.
l. liver.
mes. flattened mesoderm cells clothing the swim-bladder.
œs. œsophagus.
ov. ovary.
pigt. pigment.
pyl. pyloric cœca.
pyl. o. pyloric opening in stomach.
sb. swim-bladder.
spl. spleen.
stom. stomach.
sup. c. superior occipital bone of skull.
vert. vertebræ.
x. orifice of swim-bladder near anus in *Clupea.*
y. opening of pneumatic duct in swim-bladder.

DESCRIPTION OF PLATES.

Plate 20.

Fig. 1. Haddock (*Melanogrammus æglefinus*, Linn.) dissected to show the ductless swim-bladder *in situ.*

Fig. 2. Perch (*Perca flavescens*, Mitch.) dissected to show the ductless swim-bladder with slightly bifid anterior end.

Fig. 3. Herring (*Clupea harengus*, Linn) dissected to show the swim-bladder with anterior process, the duct (d) opening into the stomach, and the posterior opening (x) on the left of the anus (a).

Fig. 4. German carp (*Cyprinus carpio*, Linn). The swim-bladder (s b) connected by duct (d) with the œsophagus (œs) and with the ear by a chain of ossicles (i. k. l.). (Modified from Weber's well-known figure).

Fig. 5. Ventral view of skull and anterior vertebræ of the loach (*Cobitis barbatulus*, Linn.), showing osseous bullæ which cover the swim-bladder. The bullæ are expansions of the lateral processes of the 2nd. and 3rd. vertebræ.

Plate 21.

Fig. 1. Diagram, showing the diverticulum or rudiment of the swim-bladder on the dorsal wall of the œsophagus of an embryo fish, viewed from above.

Fig. 2. The same, viewed laterally.

Fig 3. Diagram, showing the bifid diverticulum or rudiment of the lungs on the ventral wall of the œsophagus of a frog. Viewed from below. (Modified from Wiedersheim).

Fig. 4. Section (trans. vert.) of the œsophagus of an embryo haddock (*Melanogrammus*) inside the egg, three days before hatching, showing dorsal diverticulum or swim-bladder (s b.) and ventral diverticulum or liver (l) The section was cut in a somewhat oblique vertical plane.

Fig. 5. Section (trans. vert.) of larval haddock, three days after hatching showing more advanced condition of swim-bladder, liver, gall-bladder, and covering of flattened mesoderm cells. x 200.

Fig. 6. Section (trans. vert.) of portion of swim-bladder of gurnard (*Trigla gurnardus*) 6 mm. long. x 175.

Fig. 7. Section do. do. of cod (*Gadus morrhua*) 6 mm. long. x 175.

Fig. 8. Section do. do. of pollack (*Pollachius virens*) 6·5 mm. long. x 200.

Fig 9. Section do. do. of cod, 9 2 mm. long. x 200.

Fig 10. Section do. do. of gemmous skulpin (*Callionymus lyra*) 7 8 mm. long. x 200.

Fig. 11. Forepart of larval haddock (from life), 7 days old, showing the swim-bladder (sb.) above the stomach (stom.) and densely covered with black pigment.

Fig. 12. Section of portion of swim-bladder of gurnard (10 mm. long) showing five distinct layers in the walls.

Fig. 13. Post-larval cunner (*Tautogolabrus adspersus*, Walb.) showing swim-bladder (s b) in transparent body of the fish. x 8.

Plate 22.

Fig. 1. Dissection of stomach, swim-bladder, &c., of the conger (*Conger vulgaris*, Cuv.) showing two globular vascular bodies (a. a) near the opening of the duct in the swim-bladder (s b.)

Fig. 2. Swim-bladder of *Corvina* (after Cuvier and Valenciennes).
Fig. 3. " " " a Sciænoid (after Günther).
Fig. 4. " " " *Pogonias chromis* (after Günther).

*Plate 23.**

Fig. 1. Abdominal viscera of young sturgeon viewed from above, showing capacious swim-bladder (s b.)

Fig. 2. The same showing upper side of swim-bladder (s b.) cut away to show the interior with opening of pneumatic duct (y.) and radiating fibres.

Fig. 3. Newly hatched gaspereau (*Pomolobus pseudharengus*, Wilson) showing large swim-bladder (s b.) and anterior cornu (*corn.*) x 20.

Fig. 4. Post-larval smelt (*Osmerus*) 15. 5 mm. long. x 7.

Fig. 5. Post-larval Thwaite-shad (*Clupea finta*) 20 mm. long, showing small elongated swim-bladder (s b.) x 5.

Fig. 6. Post-larval goby (*Gobius*) 11 mm. long with conspicuous ovoid closed swim-bladder (s b.) x 10.

Fig. 7. Head of climbing perch of India (*Anabas scandens*) showing supra-branchial organ above the gill-chamber proper.

Fig. 8. Swim-bladder (s b.) of *Heterobranchus* divided into two globular sacs.

Fig. 9. Swim-bladder of *Malapterurus* showing a third chamber posterior to two incomplete rounded sacs, outer tunic partly lifted away and exposing second layer.

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*Figs. 1 and 2 after J. A. Ryder (Bulletin U. S. Fish Comm. Vol. VIII, 1888.) ; 4 and 5 after Ernst Ehrenbaum, (Wissenschaft. Meeresunsuch, Erster Band Hef., Beitr. 3. Naturgeshichte einig). Elbfishe, 1894) ; 6 after E. W. L. Holt (Sci. Trans Roy. Dub. Soc Vol. IV , 1891); and 8 and 9 after Redouté in Histoire Naturelle (Egypt): Poissons, by Geoffroy St. Hilaire.

The Earthquake of March 21, 1904, in Nova Scotia.*—

By Prof. J. Edmund Woodman, A. M., S. D., *School of Mining and Metallurgy, Dalhousie University, Halifax, N. S.*

(Read 11th April, 1904.)

Early on the morning of March 21st, 1904, a widespread earthquake was felt in New England, New Brunswick, and Nova Scotia. On the whole, its violence was considerably greater in the first named region than farther east. In the Maritime Provinces, it was greatest in certain districts, rather erratically distributed.

Such an earthquake naturally excited much interest, and newspapers gave considerable space to accounts of its effects. The United States Geological Survey began an investigation of it, through Professor Harry Fielding Reid, of Johns Hopkins University, Baltimore, Maryland. For the purpose of compiling all possible information in a systematic manner, a blank sheet is sent to observers whenever an earthquake is to be studied by the Survey. Dr. Reid requested the author to gather such data as could be found for Nova Scotia, and in the pursuit of this task the information was collected which forms the basis of this paper. It is published with Dr. Reid's permission.

It is impossible to thank, individually, all who have been of service in this connection. Especial mention should be made of that given by Dr. A. H. Mackay, Superintendent of Education for Nova Scotia, who very kindly placed the Journal of Education, the official organ of the department, at the author's service for distributing questions; and who collected the answers

* Contributions from the Science Laboratories of Dalhousie University.—[Geology and Mineralogy].

wherever possible. Names of many observers will appear in the text. To all these, and to others, many thanks are due. On the phenomena in New Brunswick, a short paper has appeared by Mr. S. W. Kain ("Recent Earthquakes in New Brunswick"; Nat. Hist. Soc. of N. B., bull., vol. V, no. 11, June, 1904 ; pp. 243-245). It is to be regretted that more notes are not available, especially in the gold districts or region covered by them, between the Atlantic Ocean on the south and the carboniferous rocks on the north. The author will be greatly obliged to any who send him information from such or other places, and it will be used in a supplementary paper later.

For the purpose of serving as a guide to observers on future occasions, the questions sent out are here reproduced. They have been slightly amended from the original, to be better adapted to the local conditions. Most of the information obtained thus far regarding this earthquake is too meagre to permit of classification under the seperate answers, and will be given as it was received.

QUESTIONS REGARDING THE EARTHQUAKE OF MARCH 21, 1904.

1. *Location of the Observer.*—County and location in county; township.

2. *Situation of the Observer.*—(*a*) Indoors (and on what floor of the house) or in open air, on a wharf or boat, in a mine and how deep. (*b*) Position and occupation at the moment of the shock.

3. *Time* at which shock was felt, eastern Standard time.

4. *Nature of the Shock.*—(*a*) Was any tremulous motion felt before the principal disturbance and for how many seconds ? (*b*) How many principal or prominent disturbances were felt, and for how many seconds did they last ? (*c*) Was any tremulous motion felt after the principal disturbance, and for how many seconds ? (*d*) Did the movement gradually increase in intensity and then die away, or (*e*) were there two or more maxima of intensity or series of disturbances ; and, if so, what was the interval between them and the order of their intensity ? (*f*) Was the principal disturbance strongest near the beginning, the middle, or the end of the series ? (*g*) Was any vertical motion perceptible, and, if so, was the movement first upward and then downward, or vice versa ? (*h*) What was the apparent direction of the movement ? (*i*) In what direction were objects overturned ?

5 *Duration of the Shock* in seconds, not including that of the accompanying sound.

6. *Intensity of the Shock.*—Was it strong enough : (*a*) To make windows, doors, fire-irons, etc., rattle ? (*b*) To cause the chair or bed on which the observer was resting to be perceptibly raised or moved ? (*c*) To make chandeliers, pictures, etc., swing, or to stop clocks? (*d*) To overthrow ornaments, vases, etc., or cause plaster to fall from the ceilings ? (*e*) To throw down chimneys, or make cracks in the walls of buildings ?

7. *Sound Phenomena.*—(*a*) Was any unusual rumbling sound heard at the time of the shock, and, if so, what did it resemble ? (*b*) Did the beginning of the sound precede, coincide with, or follow, the beginning of the shock, and by how many seconds ? (*c*) Did the end of the sound precede, coincide with, or follow, the end of the shock, and by how many seconds ? (*d*) Did the sound become gradually louder and then die away ? (*e*) Did the instant when the sound was loudest precede, coincide with, or follow, the instant when the disturbance was strongest, and by how many seconds ? (*f*) Did the sound change in character at or about the time when the disturbance was strongest ?

8. *Miscellaneous.*—Note any other phenomena which may be related to the earthquake, such as effects on animals, on springs or streams, any change in the wind, (if so, to what direction), permanent displacements of the soil, etc. If the observer was on a boat or wharf state especially the intensity, apparent direction, etc., of shocks and noises.

9. Name and address of observer.

Please answer as many questions as possible ; number and letter the answers to correspond with the questions and forward to :

DR. J. EDMUND WOODMAN,
Dalhousie University,
Halifax, N. S.

Observations on the earthquake follow. For convenience, one or two are given from New Brunswick.

Moncton, N. B.—(Halifax Herald, Mch. 21). "A severe shock of earthquake was felt here ten minutes after two this morning. Houses trembled and furniture rocked, awakening many people from sleep. The vibration continued ten or fifteen seconds, but no damage was done."

Some dishes are said to have been broken in *St. John.* At *Fredericton*, many people rushed out, and lamps and dishes were broken. At *Woodstock* also the shock was severe.

Yarmouth, N. S.—(Halifax Chronicle, Mch. 22). "Many people were awakened early this morning by the shock of earthquake. It was of short duration, but was plainly felt in different parts of the town and country about two o'clock."

Shelburne.—Replies to questions were condensed into the following, numbers referring to question blank.

(2b) Lying in bed at the time, and awakened by the trembling motion.

(3) About 1.15 a. m.

(4) Lasted about 15 seconds.

(6a) No rattling.

(6b) Bed moved.

(6c) No pictures disturbed.

(6d) No moveable articles overthrown.

(7) No sound. [C. S. Bruce.]

It was evidently not felt at *Liverpool.*

Lunenburg.—(Lunenburg Progress-Enterprise, Mch. 23). "At *Kentville* and all through the valley it was felt, and in some places the dishes rattled in the cupboards. The vibrations were distinctly felt at *Bridgewater* and as far south as *Lunenburg*, where several of our citizens, among whom were Mr. Fenwick Zwicker and Mr. George Miller, were awakened by the rattling of dishes, and a sensation that something unusual was happening. The vacillation lasted several seconds, and in every place was five minutes past one on Monday morning."

No other place on the south shore has yet reported the occurrence except *Mahone Bay*, where a slight shock was noted by a teacher.

It has been impossible to get information of a positive nature from *Halifax*, the only data being contained in the following

by Mr. John MacAloney. His house is at Fairview, immediately north of the Halifax city limits. "I was in bed at the time; know it was after midnight, as I heard the clock strike twelve before going to sleep. Was awakened by feeling the house jar, at the same time hearing a faint sound that I took to be distant thunder. I attached so little importance to it that, had I not seen the notice of an earthquake in the papers, I would not have thought of the matter again." He explained verbally that the house felt the jar of every train, and he was very familiar with that sensation. Neither the trembling nor the sound could have been produced by a train. The house is bedded on solid rock.

To date, no note of the occurrence has been received from the country covered by the gold-bearing rocks, east of Halifax.

The most western locality on the north, from which data come, is *Digby*.—(Halifax Herald, Mch. 21). "A slight shock of earthquake was felt here, and all through the country, about two o'clock this morning, quickly followed by another of short duration. No damage whatever resulted beyond the alarm occasioned some people. In some instances in the country districts, people fled from the houses for fear they would fall."

At *Bear River*, a few miles south of Digby, and on the edge of the old rocks, the shock was distinct and heavy, sufficient to twist a bed perceptibly in at least one instance. The occupant, a wakeful invalid, knew it was tight against both end and side walls when he first went to sleep; and it was more than an inch away from the side wall, but still against the end wall, after the shock. Two periods of vibration were felt, and the attitude of the bed suggested west to east motion, which suggestion was emphasized by the sensation caused by the trembling.

Bridgetown, Annapolis Co.—(Halifax Herald, Mch. 21). "There was a very distinct shock of an earthquake felt here at just two o'clock this morning. Several persons were awakened by the trembling motion of the earth, which lasted probably about ten seconds. No damage is reported."

(Weekly Monitor, Bridgetown, Mch. 23). "The earthquake shock felt here on Monday morning . . . . The time varies from 1.05 a. m. in parts of Maine to 2.05, the time it occurred here." Mention is made also of a shock at *Belledale*, "between two and three o'clock," severe enough to wake up many.

A teacher reports the shock at *Paradise West*, and another at *North Williamstown* in the same county.

Annapolis.—(Halifax Chronicle, Mch. 22). "About two o'clock this morning (the 21st), a shock of earthquake was distinctly felt, shaking the furniture and arousing many from their slumbers. The vibrations lasted several seconds."

Cornwallis, Kings Co.—(1) Center of Cornwallis valley, equidistant from North and South Mountains.

(2) In a house, second story; awakened from sleep by shock.

(3) About 2.00 a. m.

(4) Three distinct shocks.

(5) About twenty seconds.

(6) Pictures were displaced on the wall. Some doors were opened.

(7) Rumbling sounds. [Miss Bessie Cochran, Church St., Cornwallis.]

At *Middleton* and surrounding villages, including *Nictaux Falls*, a few miles south, the shock was severe, frightening women and children. Here a bed shook violently sideways, but the occupants were too agitated to tell the direction of motion. No upward motion was felt. Total duration of disturbance may have been five minutes. There were two principal periods of vibration, with maxima only a few seconds apart.

It was reported from *North Kingston*, Kings Co., by a teacher, as also from *Wolfville*. No report was received from *Windsor*, within a few miles of the latter place, however.

At *Truro*, only one person has reported the shock.

(2) In bed, awake.

(3) Between two and three o'clock a. m.

(3a) No.

(3b) Two principal disturbances, lasting about ten seconds each, with about five seconds intervening.

(3c) Yes.

(3d) From west to east, distinctly.

(3e) No objects overturned.

(5) About 25 seconds.

(6) "It seemed as though someone took hold of side of bed and shook it violently, lifting it up and down; as though it were taken hold of on the west side. Everything was still, and then in a few seconds the same thing happened again. It woke a person in this house and another in the next house."

(7) No sound noticed. [Mrs. S. V. Mack, Park St., Truro].

It appears not to have been felt at Westville, Stellarton, or New Glasgow, in the Pictou carboniferous basin. Inquiry shows it not to have been felt at Pictou. At one time there was expectation of receiving data from one locality in Prince Edward Island, but none have come, and it is probable that the shock was not felt there. I have heard a statement, as yet unverified, that it was detected at *Springhill*. It was not felt, I believe, along the Chignecto shore from Joggins Mines to Apple River.

At *Middle Musquodoboit*, at the home of Mr. Robert Kaulback, the table in the hall shook, and a bed. The motion was from the side, and appeared to come from the west.

The Halifax and Sydney papers gave circumstantial accounts of the shock in the Sydney district; but careful inquiry at Sydney, North Sydney, Sydney Mines and Glace Bay indicates that there was no basis for the story.

* * * * * *

Too few data are available for much discussion of the geological aspects of the earthquake; but enough are at hand to indicate a few points of interest. Further consideration must await the accumulation of information from a larger number of sources.

(1) The variations of time are to be accounted for by the differences between the two standard times, between the standard and local times, or errors of time-pieces. The correct time is 1.04 to 1.05 a. m., eastern standard, or 2.04 to 2.05 a. m., maritime time.

(2) The shock appears to have consisted of two periods of disturbance, of perhaps ten seconds, separated by five seconds interval; but there may have been some little variation in different places.

(3) The shock travelled from west to east, roughly. This is not only away from the region of greatest intensity, in the United States, but is parallel to the general strike of the geological formations in Nova Scotia affected.

(4) It was felt with special severity along the line of the triassic estuary.

(5) It was more effective along the strike than across it. It was felt on the south coast, and again on the north side of the gold-bearing series for a long distance; while there is no information of its occurrence in the inland zone between.

(6) Its intensity apparently decreased eastward.

(7) There appears to be a close relation between intensity and the presence of intrusives. The zone of greatest disturbance is a long and very narrow east and west belt, from Yarmouth to about Kentville. This zone is occupied largely by triassic sediments, and bounded on the south by the plateau composed of siluro-devonian and gold-bearing strata, probably pre-cambrian. On the north is the triassic trap of North Mountain; and the old rocks to the south have, near the

escarpment of the plateau, the northern edge of the great western granite massif, which runs from near Windsor to a point a short distance east of Yarmouth.

(8) The line of disturbance on the south shore of the province remains unaccounted for. Additional data may show the back country to have been affected, or they may not.

(9) No information whatever has been given by observers underground or on the water. It is particularly desirable that data should be collected from these two sources, with a view to establishing direction and relative intensity of shock, and character of sensation, as compared with observations in houses.

On the Age of the Conglomerate Capping the Cambrian Rocks of Nova Scotia.—By Henry S. Poole, D. Sc., Assoc. R. S. M., F. R. S. C., *Halifax.*

(*Read 16th November, 1903.*)

Patches of a compact conglomerate, in places exceedingly hard to excavate, occur resting on Cambrian strata at various heights, in the neighborhood of Halifax. As the surface soil is generally thin, it is easily seen that the exposures are of detached masses, outliers of a deposit that originally must have extended to a considerable elevation. How wide was the range of the deposit has yet to be determined, but the variation in height cannot have been less than two hundred feet, counting from points well up on the peninsula to discoveries under water at Richmond shipping wharves. This range in elevation and location agrees with the investigations made by Mr. Walter H. Prest, [1] at Bridgewater on the LaHave river; and the deposit bears, in some points, similarity to one found under like conditions, well away from the coast at Gay's River.[2] This conglomerate early attracted attention for the gold which it contained, and it was shown by Mr. C. F. Hartt in 1864 to underlie the limestones and plaster of the Lower Carboniferous age.

Dr. D. Honeyman, speaking of the Digby shore near the border line of Yarmouth County, says: "I recognized the strata at Cape Cove as a counterpart of the Carboniferous auriferous conglomerate and breccia of Gay's river in Colchester County," (*Trans. N. S. Inst. Nat. Sc.*, vol. v., p. 240); while Dr. Bailey, referring to the same deposit, calls it post glacial[3].

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(1) *Trans. N. S. Inst. Nat. Sc*, vol. v., p. 240.

(2) Ib, vol. vii., pp. 42 and 44.
" vol. v., p. 328 refers to the Grand Lake "prehistoric pottery" showing modern concretions.

(3) Bailey *Rep. Geol. Sur. Can.*, vol. ix, M., 74.

On September 24th, 1878, this Institute had an outing of its members [1] and the secretary reported that on following the shore from Purcell's Cove towards Falkland village, on the western side of Halifax Harbour, "attention was directed by Dr. Honeyman to a conglomerate recently formed by the accumulated debris of granite, gneiss and slate cemented with oxide of iron derived from pyritous gneissoid rocks."

In volume vii of our *Transactions* for 1886, p. 44, Dr. Honeyman refers to a remnant of Lower Carboniferous conglomerate, resembling that of Gay's river, occurring near Grand Lake station, that reaches within a short distance of the railway. The glaciation of the argillite surfaces around, shows, he says, the nature of the agency that has been at work in the isolation of this remnant of the Carboniferous period.

These views of Dr. Honeyman were written subsequent to his paper of November, 1885, on Glacial Action, wherein, on page 254 of the *Transactions*, vol. vi, he treats of the breccia at the head of the North West Arm, east side; and that lying between Richmond and H. M. Dockyard on the west side of Halifax Harbour. This he considered to be like other conglomerates, formed by the action of sea agency, and which he was disposed to regard as the remains of an ancient formation, *e. g.*, Carboniferous. Now he says he is persuaded that the rock is a glacial debris, cemented together by oxide of iron. Sections indicated the breccia filling the hollows of the underlying argillites.

On putting these various references together, it would appear that while Dr. Honeyman notes the strong similarity of the isolated and lowest of the deposits which directly rest on Cambrian strata, he classes some as belonging to the Lower Carboniferous period and others as of the Pleistocene, but how he distinguishes between them he does not explain.

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(1) *Trans. N. S. Inst. Nat. Sc.*, vol. iv, p. 491

No detailed consideration has been given to this basal deposit in the writings of Dawson and Belt or in the reports of Professor Bailey and Mr. Faribault for the Geological Survey of Canada, and the only paper we have had bearing more than superficially on the matter is one by Mr. W. H. Prest on the Glacial Succession of Central Lunenburg; a paper that shows careful examination of certain deposits met with in the actual course of prospecting for gold leads under the guidance of experience and a study of the latest literature on glacial phenomena.

Mr. Prest correlates the Halifax rock with the Bridgewater conglomerate which he classes as the most ancient, one that formerly masked a large part of the province, covering the country to a considerable depth, as in the LaHave valley he found it from sea level to two hundred feet above it. It is always in contact and cemented to the bed-rock and almost immovable without the aid of dynamite, and yet in spite of its extreme hardness, it has been excessively divided and now is left only in patches. In origin as glacial, he considers "the presence of striated boulders testifies with no little weight, and from a northern source proved by its contents, which consist of slate from near by, quartzite from the northwest, granite from the central watershed, diorite from the south side of the Annapolis valley and trap from near the Bay of Fundy. In no more striking manner can its immense relative antiquity be illustrated than by comparing its highly oxidized condition with that of the overlying till.'

So far no deposit of this character has been detected near Halifax to rest on the granite intrusions, and this, perhaps, is not a matter of surprise, for the binding material that cements the stones together is iron oxide, evidently derived from the decomposition of pyrite which is prevalent in much of the graphitic strata. Indeed it is considered by the stone workers of the place that a similar action is now going on where trickles of water pass rusty from nodules of pyrite. The binding together of the coarse material composing the conglomerate in

question, has been very thorough, and the rock, strong and durable, is in marked contrast to the rest of the superficial drift classed with the Pleistocene which ordinarily about Halifax shows little trace of cementation, although Mr. Prest found interbedded bands of bog iron ore and cemented gravels in the LaHave till.

As to the time of deposition, the general impression among observers has been that the formation as a distinct rock was subsequent to the earliest period of the ice age, when the older rocks were rubbed down, furrowed and scratched by the passage over them of stones in the grip of Pleistocene ice. Now the object of these remarks is to ask for a reconsideration of this generally accepted view, and offer reasons for thinking that the age of the lowest of some of the deposits on the Cambrian may belong to a period more remote than the Pleistocene—a conclusion that would be very effective in a consideration of the vast antiquity of the main physical features of this province.

In composition much of the conglomerate appears to be largely made up of fragments from the slate group of the Cambrian. A granite pebble was found with some quartzite at the Halifax Dockyard, but only a few well-worn pebbles and small boulders of quartzite were detected in the conglomerate on the Dartmouth shore. Very possibly the patches of conglomerate owe their preservation largely to their position on the slates whence came the ferruginous cementing water, while it may be that the original extensions of the same deposits on the granite and quartzite, where there were no cementing waters, more readily suffered erosion and were removed. This point wants looking into, in order to read aright the full story which this rock has to tell of past conditions. The few quartzite stones that were noticed at Dartmouth were some three hundred yards south from the edge of the quartzite group crossing the Narrows, and being well water-worn contrasted with the slate stones of the bottom portion of the deposit, which were

excessively weathered but angular in shape, and forming a breccia of local and untravelled fragments.

All who have seen the contact on the Dartmouth shore have noted the very ragged surface of the slate under the conglomerate, how excessively weathered it is, the sharp edges of the ridges standing up in a shattered condition and gradually blending with the mass of breccia filling between them the V-shaped gullies and fissures to a depth of several feet. The lower portion of the deposit is undoubtedly local and distinctly brecciated, while the upper part is of fragments more or less water-worn, but still strongly cemented together. There is no gradual passage into the loose condition of ordinary till. In very marked contrast with the weathered surface under the breccia is the eroded and often striated slaty lip of the depression that retains the deposit at this place.

If a rapid review of the Atlantic coast be made, we have in the extreme west a conglomerate deposit on the slates at Cape Cove which Dr. Honeyman considered Lower Carboniferous. On the LaHave there is one regarded by Mr. Prest as the oldest glacial and of great antiquity; at the head of Chester Basin are other deposits of conglomerate associated with Lower Carboniferous limestone; at Halifax there are conglomerate outliers of an age now up for discussion, while at the outlet of Kelley's Lake, near Grand Lake, and Gay's River, are deposits hitherto accepted as Lower Carboniferous. Then on the Cambrian and Pre-Cambrian of the seaboard of Cape Breton at Gabarus, Flamboise, etc., there are, according to the Geological Survey, outlying patches of Lower Carboniferous strata.

Most of the known patches of this conglomerate about Halifax rest on a highly weathered surface without trace of marine denudation or glaciation; but of the deposit itself at LaHave Mr. Prest has pointed out that the stones of the upper portion are striated and therefore glacial. Hence, he has concluded that his Bridgewater conglomerate is not Lower Carboniferous but the very earliest deposit of the Pleistocene.

There are two typical exposures in this neighborhood worthy of close study. One is made by the railway cutting at the entrance of North street station, and the other is across the harbor on the Dartmouth shore opposite the Dockyard. Both clearly show weathered slate ridges rising up shattered and settling to blend with the breccia filling the intervening fissures.

The Halifax conglomerate occurs at the Imperial wharf at Ferguson's Cove and northward in spots to the last exposure of rocks near Purcell's Cove; on the west side of the North West Arm about Melville Island; on both sides at the head of the Arm, and half way up the hill on the side of the road to Chain Lakes. Again on the Dutch Village road near the Three Mile House; in the railway cutting out of North Street station, and on the shore of the harbor north of the sugar refinery at Richmond. At the latter spot the conglomerate is twelve or more feet thick and is seen to rest on a smoothed and much striated surface of slate. At a greater elevation in the railway cutting mentioned, the glacial abrasion has not removed the previously weathered and shattered rock surface of a preceding age, and a cemented breccia occupies the ancient runlets and V-shaped channels in the weathered slates identical with the exposure of the conglomerate at sea level on the opposite Dartmouth shore. When one considers the durability of the slate,(1) and the very slight decomposition it has undergone on the uncovered glaciated knolls, and then note the great depth in these rocks to which the pre-glacial weathering extended before the deposition of the conglomerate, one is forced to extend an extreme age to the pre-conglomerote cycle of exposure.

The student of glacial phenomena will be interested in noting in the drift composing the islands of Purcell's Cove, transported blocks of this conglomerate indicating the comple-

(1) The durability of the slate of this region is well illustrated by the tombstones made of it and set up one hundred and thirty years ago, They show the light lines scratched for the guidance of the sculptor as sharp as though made recently.

tion of a cycle of conditions which terminated in the disruption of the conglomerate deposit and its transportation in the moraine matter that came along the edge of the granite from the northwestward. Also in excavations in mounds on the north side of Tower Road, Halifax, where rusty and cemented slate fragments form a distinct layer over the dark blue slate debris which rests directly on the uneroded slate surfaces.

The generally accepted supposition that the conglomerate outliers are all of one age, may be met by an assumption that among the basal conglomerate of the Lower Carboniferous some may have been glacial deposits. This is no new view, but the evidence so far obtained is said to be inconclusive. In this province we have on the Cambrian rocks conglomerates associated with plaster and limestone of unquestioned Lower Carboniferous age as at Chester Basin. Mr. Fletcher's report on Cape Breton,[1] speaks of scattered patches of conglomerate, etc., resting on pre-Silurian felsites—many of which he has no doubt are of Carboniferous age. To that horizon also are placed the conglomerates resting on the Cambrian rocks at Gay's River, etc. It seems, therefore, reasonable at least to suspect some of the conglomerate outliers on the Cambrian in the same range of country, may be also older than the Pleistocene.

In the paper already cited, Mr. Prest puts forward the importance of these deposits and the bearing they have on the study of auriferous washings, and it is to be regretted that other records have not been made in the same thorough way when tracing float or auriferous drift to its source in the nearby solid lead.

However much observers may differ as to the age of this lowest of the unconformable deposits on the Cambrian rocks, all must be agreed that the physical features of the province, as we now have them, were already rough hewn before the deposition of the lowest of the Carboniferous, and that what-

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(1.) *Rept. Geol. Surv. Can.*, 1877-8, F., p. 23.

ever the extent of subsequent deposits may have been succeeding cycles in their denudation, did little more by their removal than revert to the Cambrian surface of the Pre-Carboniferous peneplane. The lines of main drainage are of subærial erosion established before this period, and the general surface suffered comparatively little by the subsequent passage over it of the ice sheets, beyond the removal of much, but not all, of the weathered and broken superficial material. The patches of deposit we have been considering in their relation to the Cambrian at various elevations, make probable such a conclusion.

A visit paid to the neighborhood of the head of Grand Lake and to Kelly's Lake, lying back of Wellington station, disclosed a conglomerate cemented with bog iron ore at the crossing of the abandoned old road over the brook from Kelly's Lake. At the outlet of Kelly's Lake, apparently daming back the waters of the lake, occurs the conglomerate referred to by Dr. Honeyman. It surface was seen to be rounded and a good specimen was obtained smoothed and grooved. The character of the rock, with its hematitic pebbles, bears a striking resemblance to some of that about Gay's River, and left no doubt in my mind that it also was, as Dr. Honeyman regarded it, of Lower Carboniferous age, while the deposit lower down the brook was Post-Pliocene. The contact of the upper rock with the Cambrian slates was not found exposed, but the strip appeared to be quite narrow, while it extended for a quarter of a mile or more to the westward. Other exposures of the bog ore deposit are reported to occur in the neighborhood, and west of Wellington station.

During the past summer, attention was directed for commercial purposes to deposits of bog iron ore which occur in a strip of country two miles wide along the south side of the Musquodoboit valley. These deposits are in low swampy depressions of the blue black graphitic and ferruginous slates of the Lower Cambrian, east and west of the Caribou gold district with which they range.

Deposits were found at Newcomb's Corner, Fall River, etc., in a conglomerate largely made up of bits of slate, and prospecting licenses extended some twenty-five miles.*

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*In the *Summary Report of the Geological Survey* for 1903, Mr. Faribault mentions eleven localities from which bog iron ore was obtained, and which yielded to Dr. Hoffmann an average analysis of the whole eleven specimens no less than 52 per cent. of metallic iron. See *Sum. Rept.*, 1903, p. 185.

On a Determination of the Elements of Terrestrial Magnetism at Halifax, N. S., August, 1904. By Prof. Stephen M. Dixon, M. A., *Dalhousie College, Halifax.*

(*Read 21st November, 1904.*)

The observations of the Magnetic Elements recorded in this paper were made at Point Pleasant, Halifax, August 25 and 26, 1904. The magnetometer and dip circle used were obtained through Professor C. H. McLeod, from McGill University, the chronometer was lent by Mr. C. G. Shultz and the theodolite by Mr. W. A. Hendry, C. E.

As it is hoped that these observations will be followed by a complete magnetic survey of the Maritime Provinces, and as this is the first time the matter has been brought before the Institute of Science, a brief sketch will be given of the phenomena of Terrestrial Magnetism. In preparing this sketch the writer has borrowed largely from the Magnetic Declination Tables and Isogonic Charts by Dr. L. A. Bauer. The practical importance of one of the elements, usually called by land surveyors the variation of the compass, cannot be overestimated in this province, where those who are interested in land and mine surveying know the trouble that is continually arising on account of the neglect of this very matter. In other countries terrestrial magnetism has been studied in connection with geology and many interesting discoveries have been made. Magnetic surveys have led to the devising of magnetic methods in prospecting for iron ores. To the student in physics and to the astronomer, the subject is equally interesting, on account of the relation of surface changes on the sun to variations in the earth's magnetism. The subject then is of general interest and its importance has been emphasized by the establishment, in December last, by the trustees of Carnegie Institution, of a Department of International Research in Terrestrial Mag-

netism. Dr. L. A. Bauer, Chief of the Division of Terrestrial Magnetism, U. S. Coast Survey, was appointed to control this department and an annual grant of twenty thousand dollars alloted to carry out the work.

Magnetic Declination.

In Europe the science of terrestrial magnetism began with the discovery of magnetic declination in 1492. In this year Columbus, on his first great voyage, found that except in certain places the compass needle did not point to the pole and that the angle it made with the true meridian varied from place to place. Eighteen years later, in 1510, George Hartmann made the first recorded measurements of magnetic declination on land. At Rome in this year, he found the declination 6° E. and at Nuremburg 10° E. In the succeeding years many observations of declination were made, and in England the first work published on the subject was by William Borough, "A Discours of the Variation," in 1581. In this book the value of the declination at London for 1580 is given as 10° 15′ E. By such observations all over the earth, at sea and on land, the declination was noted, and in 1599 Simon Stevin published at Leyden, under the patronage of the Dutch admiral, Count Moritz, a list of magnetic declination determinations. This early interest in magnetic observation has been kept up by the Dutch. At home and in their colonies magnetic work has been carried on energetically, and at the present day the survey of Holland is the most complete in Europe. Dr. L. A. Bauer has published [1] a very complete list of magnetic declination observations made before the year 1600, and points out that the declination over the greater part in Europe in the sixteenth century was east of north.

Dip.

The second element of the earth's magnetism, the inclination or Dip, was discovered by Robert Norman, an instrument

(1) Magnetic Declination Tables for 1902, by L. A. Bauer. *U.S. Coast and Geodetic Survey.*

maker and hydrographer of London. Norman published his discovery in a treatise called "The Newe Attraction," printed in 1581, and gives the value of the dip at London in 1576 as 71° 50′. Norman's discovery had been anticipated by George Hartmann, for in a letter to Count Albert of Prussia, March 4, 1544, in which he recounts his observations of the declination, he mentions that the needle, besides deflecting towards the east, also pointed downwards. Hartmann, however, did not suspend the needle so as to observe the dip correctly and only recorded an amount of 9° instead of about 65°, the value he ought to have found.

Intensity.

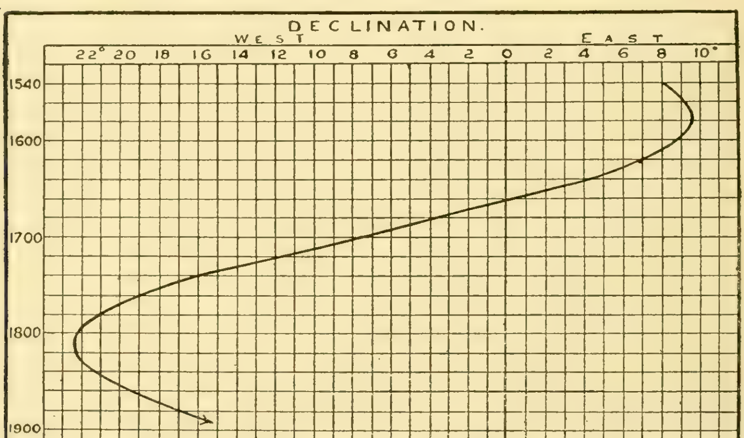
The third element, the Intensity of the earth's magnetic force, was first measured by William Whiston. In 1720 a prize was offered for the best way of determining longitude at sea. Columbus, in 1592, had first suggested using the lines of equal declination for determining longitudes, but Gilbert, who published his great work "De Magnete" in 1600, proposed to determine longitude by variations in the angle of dip. Whiston, taken with this latter theory, constructed many dip circles, and as a result of his observations, showed how the intensity with which the earth attracted a magnetic needle varied from place to place. As a matter of convenience, it is the horizontal component of the earth's magnetic force that is measured, and the unit in which the measurement is made is called a *gauss*, after the celebrated physicist who first showed how the *absolute* intensity of the earth's magnetism might be found.

Secular Change in Declination.

A magnetic survey of a country aims at making determinations of the three elements at a sufficient number of suitable localities. But when such a survey has been completed, if the value of any one of the elements is compared with that determined at the same place on some previous occasion, a difference

in the values will be found, and the assumption of Gilbert of the invariability of 'the variation' will be found untenable. In 1634 Henry Gillibrand made a determination of the declination at Deptford and found it 4° 6′ E, whereas Borough and Norman had noted 11° 15′ E as its value in 1580. Ever since the announcement in 1635 of this discovery, this so called *secular variation* has been carefully studied, but the cause is unknown and Gillibrand's words are still true, "it must all be left to future times to discover."

The changes in declination may best be studied by constructing a diagram showing graphically the results of observations at any one place. The curve shown in the figure (1) has been drawn by Schott and represents the changes observed at Paris.



C. A. Schott's curve showing changes in magnetic declination observed at Paris since 1540.

When such curves are drawn for different places their various forms impress us with the difficulty of discovering the laws according to which this secular change takes place, and it is evident that the changes in the other elements must be studied at the same time.

(1) *U. S. Coast and Geodetic Survey*, 1882.

Isogonic Charts.

For practical purposes the secular changes in declination have long been studied. Owing to the use of the compass made in navigation the 'variation charts' must be always up-to-date, as in cloudy weather the seaman depends altogether on them and on his compass. On land the surveyor should be able to find the declination and then running his course by geographical bearings, avoid the trouble such as has already been caused in this province by using the compass without recording 'the variation. Variation charts are made by drawing on them lines passing through places where the declination is the same—isogonic lines. Halley, the celebrated astronomer, was the first to publish these charts, though this method of mapping lines of magnetic declination seems to have been used by Christoforo Borri. Dr. Bauer in 1895 discovered in the British Museum a copy of Halley's first chart, published in 1701, on which were marked the results of Halley's observations taken in the Atlantic on the *Paramour Pink*, a vessel equipped by the British government for the first systematic survey, 1698-1700. In 1702 Halley published a second chart, on which were marked the isogonic lines for the Indian and Pacific oceans. The map on plate 24 gives the isogonic lines as determined by Halley, and on plate 25 are given the isogonic lines for 1905 as computed by the British Admiralty. On tracing these lines in either chart, we notice the two lines of no declination, or agonic lines, which separate places having east from those having west declination. The very irregular distribution of equal values of declination is easily seen, the chart for 1905 showing the remarkable circular agonic line in China.

But except on land we have little real knowledge of these isogonic lines. "No magnetic data have been obtained on the ocean areas since the advent of iron ships, except from occasional expeditions. Our present lines of equal magnetic declination over these waters depend almost entirely upon data acquired in

wooden ships fifty to one hundred years ago." (1) For this reason, part of the programme of the Department of International Research in Terrestrial Magnetism is a magnetic survey of ocean areas. It is probable that very serious errors exist in these charts near the coast lines of the continents. When the declination has been determined at a large number of stations over a small area, the isogonic lines are found to be very irregular and the easy curves drawn on charts merely indicate, as a rule, the general positions of the lines. On the coast of Nova Scotia, on several occasions, shipwrecks have been attributed to an unknown variation of the compass, and it has been stated that the last great disaster at Rockall, when on the 29th of last June the Danish S. S. *Norge* was wrecked and about 600 lives lost, was due to the same cause. In *Nature* of Sept. 15th, Dr. August Krogh, of the University of Copenhagen, calls attention to this fact and publishes letters from two captains who state that they have observed changes in the magnetic declination to an amount of from 9° to 11° in the neighbourhood of Rockall.

Declination and Land Surveys.

The importance to the land surveyor of an accurate knowledge of the magnetic declination and its changes has been already noted. In many cases the value of the declination at the time when a survey has been made has not been recorded, and in some cases, doubtless, the land surveyor has but hazy ideas of the value of the declination and its changes. Much time and money has been already wasted in disputes over old lines, and still the method of describing lines by these magnetic bearings is in use in this province. The author suggests that true north and south lines should be laid down in all the principal towns, so that surveyors might test their compasses and note the changes in declination from time to time in the particular localities in which they were working. Such a line was laid down at the University of New Brunswick, Fredericton,

(1) L. A. Bauer. *Terrestrial Magnetism*, March, 1904.

by order of the Surveyor General of New Brunswick in October, 1874. In the year 1898, a magnetic survey of North Carolina was made by the U. S. Coast and Geodetic Survey and the North Carolina Geological Survey. During the survey meridian lines were established in the county towns, and the county commissioners were so impressed with the value of the work that in many cases they paid the field expenses of the survey.

Daily Variations in Declination.

Besides the great secular changes in declination we find several small changes—periodic or irregular. The first of these —the Daily Variation—was discovered in 1722 by Graham who, from a series of several hundred observations made at London, found that the declination varied during the day. The average value of the arc through which the needle swings is about eight minutes, the true declination occurring about 10.30 a. m. and 8 p. m. At Fort Conger in Grinnell Land an extraordinary value of $1^\circ\ 40'$ has been found for the daily variation.

Annual Variation.

The second of the small periodic changes to which the declination is subject, is that known as the Annual Variation, and is found by tabulating the monthly values corrected for the secular changes. The average value for Toronto is about half a minute. There is also a Lunar Variation, but this is even smaller than the annual, being only about 15 seconds from the mean.

Irregular Changes in Declination.

Besides these periodic changes in declination, it has been found that owing to so called magnetic storms, the magnetic needle is often violently affected. In these disturbances the maximum deflections of the needle from the mean position range from about $20'$ and a variation of 2° observed at Mantilik in 1896 [1] and an extraordinary deflection of $20^\circ\ 1'$ recorded by

(1) Lat. $64^\circ\ 53'.5$ N., long. $66^\circ\ 19'.5$ W.

Greely as observed at Lady Franklin Bay, 1882. A serious effect of these magnetic storms is alluded to in a recent paper by Sir Norman Lockyer, who says, speaking of 'the well marked coincidence' between the variation of magnetic effects and the quantity of spotted area on the sun, "This in later telegraphic days is not merely a pious opinion which does not interest anybody, because when the magnetic changes are very considerable, and the disturbances arrive at a maximum, it is very difficult to get a telegram from London to Brighton." (1) During the great magnetic storm of Oct. 31, 1903, telegraphic communication in Spain was interrupted from morning till midnight. At 3 hrs. 20 min. the cable from Cadiz to Teneriffe was so perturbed that the clerks grounded it to avoid the discharge. This storm at Falmouth, England, was also of exceptional violence, the declination magnet there swinging through an arc of 2° 2′. That there is a connection between disturbances on the sun and magnetic storms is undoubted, but Lord Kelvin, reasoning from the immense amount of electrical energy which the sun would have to give out if it alone were the cause of these disturbances, concludes that great magnetic storms cannot be due entirely to the direct action of the sun.

"The probability is that a solar ray endowed with greater or less energy than ordinarily and of the necessary kind acted as the 'trigger to the gun' to set off mighty electric forces whose presence in the upper regions is becoming more and more manifest every day." (2) Some of the effects of this solar influence have been noted, it is thought, during total eclipses. During the eclipse of May 28, 1900, members of the U. S. Coast and Geodetic Survey noticed a slight magnetic effect which might be attributed in some way to the changes produced in the upper atmosphere when it was shielded from the sun's rays. To try to settle this question, an extensive series of observations were made during the eclipse of May 17, 18, 1901. The obser-

(1) Paper presented to the International Meteorological Committee at Southport, Sept. 11, 1903, by Sir Norman Lockyer, K. C. B.

(2) U. S. Declination Tables for 1902. L. A. Bauer, p. 56.

vations were taken at stations all over the globe, but only three of these were in the belt of totality. The results do not seem conclusive one way or the other. At Karang Sago, the Dutch observers noted a slight change in declination and in horizontal intensity, and at Sawah Loento, the party sent by the Massachusetts Institute of Technology observed a slight decrease of east declination at a time when there is normally an increase. These effects did not extend far outside the belt of totality. On the other hand, nothing particular was noted by the observers at the Mauritius, a station directly on the belt.

It is hoped that further information will be obtained on this interesting question at the total eclipse next August. In this eclipse the belt of totality will pass over part of Labrador and so will be easily accessible. It is evident that observations outside the belt, but not far from it, in Quebec and Nova Scotia, will be of great value.

The Dip and its Variations.

When a magnetic survey is made and the dip is measured in different localities, it is found to vary in value from place to place and from time to time. When the lines of equal dip are plotted, we find them not nearly so irregular as those of equal declination. One of these lines, that of 'no dip', the so called magnetic equator, circles the earth not far from the geographical equator. Along this line the dip needle remains horizontal, and at all places north of it the north pole of the needle points towards the earth, and the south pole of the needle dips down at places south of this line, the dip continually increasing towards the poles. The north magnetic pole is in Boothia Felix, and in 1831 Ross believed that he reached it, the exact position recorded for it being latitude 70° 05′ 17″ N. and 96° 45′ 48″ W. longitude. At this place Ross found that the needle pointed vertically downward. Little was known about the south magnetic pole till quite recently, and the results of the observations of the recent Antartic expedition are awaited with interest.

Captain Scott, of the *Discovery*, the British vessel which took part in this expedition, besides establishing a record for farthest south, latitude 80° 17′, reached a point on the line between the south magnetic pole and the south pole in November 1903. The secular changes in the angle of dip are much less than those in the declination. At London the dip reached a maximum of 74° 42′ in the year 1720, since which time it has continually decreased, being 67° 9′ in 1900. Daily and annual changes in the amount of dip are also noticed.

Changes in the Intensity.

As with the other elements, so the values of the Intensity varies from place to place, and we find that the points where the intensity is greatest are not coincident with the magnetic poles, but that there are two northern "foci of greater magnetic intensity" and two southern. The secular changes in total intensity are small. At London it was ·4791 *gauss* in 1848 and ·4736 in 1880, since when it has been increasing. The daily and annual changes are very small.

Terrestrial Magnetism and Geology.

When a complete survey of the three magnetic elements—declination, dip, and intensity—is made over a considerable area, most interesting geological results are often obtained. The first such survey was that of the British Isles, made in 1836-1838. This survey was repeated in 1857-1862 and again on a great scale in 1884-1892, observations being made at 882 stations. The results of this survey were published by Sir Arthur Rücker in 1896 and one section of his report deals with the "Relation between the Magnetic and Geological Constitution of Great Britain and Ireland." In this report it is shown that where large masses of basalt occurred the north pole of the needle tended to move towards them even from a distance of over 50 miles. Hence, if local attraction is found where no magnetic rocks appear on the surface, it is probably due to concealed masses of

magnetic rocks and "the lines which we draw on the surface of a map as those to which the north pole is attracted, may, in fact, roughly represent the ridge lines of concealed masses of magnetic rocks." (1) In all countries such magnetic ridges have been noticed, and geologists now recognize fully the great importance of magnetic work. As an example of this, it may be noted that the magnetic survey of Maryland was inaugurated by the State Geologist, Professor W. B. Clark, and a very large share of the expenses was borne by the Maryland Geological Survey. This survey, which was carried out by Dr. L. A. Bauer (1896-1900) is by far the most complete in America, in fact the only country which has been surveyed with more detail is Holland.

In Japan, a recent magnetic survey has been made (1893-1896) and the three elements have been measured at more than 320 stations well distributed over the Islands. This survey was carried out under the Earthquake Investigation Committee and the results were published this year.(2) The maps have been so arranged that it is possible to compare the distribution of magnetic force with the geological structure of the country.

Magnetic Prospecting for Iron Ores.

Rücker's observations on the assistance to be derived from magnetic surveys in studying the geology of a country, were anticipated in 1843 by Van Wrede, who first saw that magnetic work should furnish valuable information with regard to the location of magnetic deposits. Practically nothing resulted from this till in 1879 Professor Robert Thälen published a paper "On the examination of iron ore deposits by magnetic measurements," and since then much work has been done in this direction in Sweden. In Canada also some valuable work has been done by the Geological Survey and Department of Mines. In the geological report for 1903(3) we find an inter-

(1) A. W. Rücker, Terrestrial Magnetism, vol. iii, p. 42.

(2) A magnetic survery of Japan, epoch 1895. A. Tanakadate. *Journal of the College of Science, Imperial University*, Tokyo, 1904.

(3) *Summary Report of Geological Survey of Canada* for 1903, p. 122.

esting account of the method employed for mapping the Temagami iron ranges. Observations were made of both dip and declination with the Thälen-Tiberg magnetometer and the formation was traced over a distance of 1½ miles, even through swamps where there were no outcrops. In several places the surface was stripped to confirm the observations. This work and a more accurate survey of the north-east iron range were carried on by Mr. Erik Nystrom, assistant to Dr. Haanel, Supintendent of Mines. The first account in English of Thälen's method has been published this year at Ottawa by Dr. Eugene Haanel.(1)

Work of a Magnetic Survey.

Sufficient has been said to show the importance of magnetic surveys. With regard to the work of a complete survey, it will be evident that three seperate undertakings are necessary, first, the determination of the elements at a sufficient number of stations properly situated to furnish reliable information over the whole area ; second, the establishment of 'repeat' stations, where the observations can be repeated from time to time so that the secular changes may be noted ; and third, the establishment of magnetic observatories so that the diurnal and annual changes may be determined and non-periodic disturbances marked. These observations, except in mining districts, would be of a temporary nature, observations being taken at them only so long as the surrounding district was being surveyed. In Germany such observations have for many years been maintained at some of the chief mines and in these are taken photographic records of changes in the declination so that the mine surveyor may take the exact value of the quantity at the time he is running any line. Several permanent observatories are also needed in Canada, and one of these should be in a suitable position in these provinces. The observatory at Toronto is the oldest(2) in America, having been

(1) On the Location and Examination of Magnetic Ore Deposits by Magnetometric Measurements, by Eugene Haanel, Ph. D.

(2) The Gerard College Observatory, Philadelphia, was the first magnetic observatory in America and was in operation from 1840-1845.

in operation since 1841. In the United States one permanent observatory has been established recently, that at Cheltenham, Md., and the Coast and Geodetic Survey has also in its charge three other well equipped observatories, Sitka in Alaska, Honolulu in Hawaii, and Baldwin in Kansas. The first two rank with the Cheltenham as permanent observatories, the Baldwin observatory being merely a temporary one.[1] Several other permanent observatories are in contemplation.

In the old world, the number of magnetic observations is being continually increased. In a short time there will be eight permanent observatories in France; the Japanese have six in operation at present.

The choice of a site for a permanent observatory is a very difficult matter. It is very hard to find a convenient locality which will not be invaded sooner or later by electric car lines. And it has been shown by Dr. Edler in 1899, that an observatory must be at least five miles from an electric tram line and that for delicate research work the distance must be twice as great. Of the great European observatories, that of Potsdam alone has been able to carry on its work properly on its original site, and this is owing to a decree of the Emperor, which forbids electric tram lines coming within 16 kils. The other observatories have been already moved or are seeking new sites. It is only a few years since the site of the Toronto observatory had to be changed for the same reason.

The Observations at Point Pleasant, Halifax.

The observations of the elements were made at Point Pleasant as being a station which could be easily occupied again The position was marked by a concrete pillar sunk 4 feet in the ground in which was bedded a copper plug. The observations were taken between 2 a. m. and 4 a. m. on the mornings of August 25, 26, 1904, so that there might be no local disturbance owing to the running of the electric trams.

(1) Magnetic observations of the U. S. Coast and Geodetic Survey, 1902. Bauer and Fleming, Washington. 1903.

A small electric hand lamp was used for reading and for illuminating the cross hairs when determining azimuth.

Results.

The *Declination* was found to be 21° 2′, local time 1 h. 40 m. a. m., Aug. 26, temp. 15° C.

This value has not been corrected for daily variation, the amount being undetermined for Halifax. This correction would be very small, as for all stations south of the 49th parallel it is found that the yearly average diurnal variation is at a minimum at about 2 a. m., being 0′·0 at Madison, Wis., and 0′·5 at Toronto.

The value of the *Dip* found was 73° 58′; this was the mean of two sets of observations, 74° 00′ and 73° 55′.

The *Horizontal Force* was found to be ·1624, Aug. 25, 1904, local time 3 a. m., mean temp. 13°·8 C.

The *Azimuth* was determined by observations on Polaris, these reductions being made by the tables published in the U. S. "Manual of Instructions" issued by the Commissioner of the General Land Office.

Isogonic Lines in Nova Scotia.

The table below gives values of the declination in the Maritime Provinces collected from various sources and from which the isogonic lines have been sketched on the map in plate 26. It must be remembered that owing to the small number of observations, it has been impossible to obtain more than approximate values for the secular change, and so the reduction of the observed values to the present year is only approximate. No attempt has been made to indicate the local variation, since so few reliable observations have yet been made, and so the curves show no irregularities. The map shows, however, the general direction of the isogonic lines in Nova Scotia and is drawn to point out the very great variation in the value of the declination in the province.

Table showing recent determinations and computations of Magnetic Declination in the Maritime Provinces.

Lon. W. °	′	Lat. N. °	′	Date	Declination. °	′	Recorder.	Notes.
60	00	45	55	1900	21	45	B. A. Chart	Decreasing slightly.
60	12	46	09	1896	21	53	G. R. Putnam*	
60	12	47	26	1900	27	25	"	
60	23	46	17	1857	24	40	J. H. Orlebar*	
60	25	46	05	1857	24	45	"	
60	47	45	33	1881	24	15	B. A. Chart	Decreasing 1′ annually.
61	00	45	25	1881	24	00	"	" "
61	00	45	08	1900	23	20	"	Stationary.
61	01	45	30	1881	23	26	S. W. Very*	
61	20	46	40	1892	25	50	B. A. Chart	Stationary.
61	20	45	40	1881	24	10	"	Decreasing 1′ annually.
61	40	45	08	1902	22	40	E. R. Faribault	
61	41	45	11	1904	22	45	B. A. Chart	Slightly decreasing.
61	50	47	15	1833	22	36	H. W. Bayfield*	
62	25	44	44	1904	21	50	B. A. Chart	Stationary.
62	33	46	11	1843	21	58	H. W. Bayfield*	
62	40	44	40	1892	22	00	B. A. Chart	
62	40	45	42	1841	20	19	H. W. Bayfield*	
62	53	44	33	1892	21	45	B. A. Chart	
63	08	46	14	1898	23	40	Nfd. Survey*	
63	20	45	15	1892	21	00	B. A. Chart	Stationary.
63	20	44	30	1893	21	30	"	"
63	20	46	30	1845	21	45	H. W. Bayfield*	
63	22	44	42	1900	21	24	W. B. Dawson*	
63	36	44	47	1881	21	01	"	
63	43	46	34	1845	21	00	H. W. Bayfield*	
63	43	46	15	1840	20	18	"	
63	48	46	24	1841	20	12	"	
63	50	46	10	1841	20	00	"	
63	53	44	52	1901	21	07	E. R. Faribault	
64	00	45	30	1900	21	25	B. A. Chart	Stationary.
64	03	46	48	1845	21	10	H. W. Bayfield*	
64	05	44	18	1904	20	00	B. A. Chart	Stationary.
64	08	45	00	1881	20	42	S. W. Very*	
64	20	44	20	1902	20	00	E. R. Faribault	
64	23	46	15	1839	19	59	H. W. Bayfield*	
64	24	44	04	1904	19	30	B. A. Chart	Stationary.
64	40	45	03	1900	20	30	"	"
64	43	47	45	1838	21	43	H. W. Bayfield*	
64	43	43	50	1904	19	00	B. A. Chart	Stationary.
64	49	46	43	1839	19	50	H. W. Bayfield*	
65	00	43	10	1904	18	10	B. A. Chart	Increasing 1′ annually.
65	00	45	50	1900	19	40	"	Stationary.
65	04	47	06	1857	21	24	J. H, Orlebar*	
65	10	43	35	1904	18	35	B. A. Chart	Stationary.
65	31	44	44	1881	19	27	S. W. Very*	
65	35	44	53	1886	20	15	B. A. Chart	Increasing 1½′ annually.
65	40	43	45	1895	17	55	"	Stationary.
65	40	45	30	1838	16	38	J. Wilkinson	
65	53	43	35	1838	18	05	"	Increasing 1′ annually.
66	00	45	15	1859	18	16	P. F. Shortland*	
66	00	44	24	1881	18	43	S. W. Very*	
66	00	45	00	1895	19	00	B. A. Chart	Stationary.
66	03	45	14	1866	19	23	J. H. Orlebar*	
66	07	43	50	1881	17	49	S. W. Very	
66	10	44	35	1904	19	10	B. A. Chart	
66	30	44	35	1897	19	49	S. M. Dixon	
66	38	45	16	1790	14	00	N. B. Land Offic	
66	38	45	16	1879	19	53	Brydone Jack	
66	38	45	16	1892	20	00	S. M. Dixon	
67	30	47	00	1875	21	00	N. B. Land Office	

* From Tables of Magnetic Declinations, by L. A. Bauer.

THE FAULTS OF BATTERY POINT, SYDNEY, N. S.*—BY T. T. FULTON, B. Sc., B. E. (Mining).

(*Read 14th March, 1904*).

The field work for the following paper was done during the spring of 1903, in the course of studies pursued in the Summer School of Dalhousie University.

The section under discussion is situated at Battery Point, Sydney, Cape Breton. It extends from a point 200 feet south of the old railway pier, for about 1,000 feet in a southerly direction. The faulted area begins 134 feet south of the beginning of the outcrop, and is about 400 feet long. Some faults, which in the accompanying section are shown as extending to the top of the cliff, may lessen or die out toward the surface; for the strata are not always easy to correlate.

The rocks are in the Carboniferous Limestone (Windsor) series. They are largely gray calcareous shales, with bands of concretionary clay ironstone, which vary from a few inches to eighteen inches thick. The ironstones have been employed to determine the displacements, as they are easily distinguished. The average strike of the strata is N. 42° W. (mag.), and the dip 11° N. The face of the cliff, near the top, is in many places covered with talus, which rests upon especially resistant strata that stand out below. It is this talus which makes it impossible, in some instances, to determine whether the faults pass unchanged to the surface or die out. In a few cases the latter condition was seen, in many the former. No other outcrops are available to determine the extent of the faults along the strike.

* Contributions from the Science Laboratories of Dalhousie University—Geology and Mineralogy.

The following table gives the data for each fault, beginning with No. 1 on the the extreme north (left, in the section):

Section Number.	Class.	Strike.	Dip.	Displacement.
I.....	Normal.	N. 78° E.	48° S.	4″
II......	"	E. —W.	52° S.	2″
III......	"	N. 48° E.	60° S.	2″
IV......	"	N. 70° E.	40° S.	1″
V......	"	N. 48° E.	60° S.	5″
VI......	"	N. 80° E.	50° S.	3′ 3″
VII......	"	N. 70° W.	48° S.	1′ 5″
VIII......	Reverse.	N. 54° W.	68° N.	3″
IX......	"	N. 48° W.	72° N.	1′ 3″
X......	"	N. 75° W.	62° S.	5″
XI......	"	N. 68° W.	44° S.	2″
XII......	Normal.	N. 82° W.	62° N.	4″
XIII......	"	N. 75° W.	58° S.	2″
XIV......	"	N. 45° W.	82° N.	7″
XV......	"	N. 62° W.	60° S.	1′ 1″
XVI......	"	N. 82° W.	58° S.	2″
XVII......	"	N. 82° W.	85° N.	3″
XVIII......	Reverse.	N. 68° W.	85° N.	6″
XIX......	Normal.	N. 60° W.	70° N.	1′ 8″
XX......	Reverse.	N. 70° W.	68° N.	2′ 0″
XXI......	Normal.	N. 88° W.	42° S.	1′ 6″
XXII......	Reverse.	N. 86° W.	58° S.	6″
XXIII......	Normal.	N. 70° W.	70° N.	6″
XXIV......	"	N. 85° W.	58° S.	3″
XXV......	"	N. 80° W.	38° S.	6″
XXVI......	"	N. 80° W.	62° S.	1′ 0″
XXVII......	"	N. 78° W.	58° N.	4″

Subsidence of the Atlantic Coast of Nova Scotia. (Introductory to a paper by Mr. McIntosh)—By Henry S. Poole, D. Sc., F. G. S.

(Read 21st December, 1903.)

When the question of modern subsidence of this country is mooted, reference is invariably made to Louisbourg as a spot where evidence of an undoubted character has been obtained. This view has been accepted, and, so far as is known, remained unchanged for forty years. It is hence entitled to the respect which goes with age, and has to be met, if it can be, by arguments as weighty as would be required to establish a similar reputation for a new locality. Yet this is an age when the reverence for traditions saves but few from re-investigation and criticism, and this one regarding Louisbourg, is, I consider, open to such a treatment.

It appears that the parent source of the statement respecting Louisbourg was a paper by Dr. Abraham Gesner, entitled, "Elevations and Depressions of the Earth in North America." It was published in vol. xvii, page 386, of the *Journal of the Geological Society of London*, 1861; only one hundred years after the second and final fall of the great fortress on which France had spent so many millions of francs to maintain her hold of possessions in North America. Now when a further period nearly half as long has elapsed, we are justified in expecting that the evidence that carried conviction to Dr. Gesner forty years ago, would be intensified and be now patent to all observers. On my own part, a casual acquaintance with the old town extending over the life of a generation, has left with me no confirmatory impression, and lately led me to seek for data on which the accepted conclusion has been based.

Dr. Gesner's remarks were as follows:—"Had Louisbourg continued to exist up to the present time, its abandonment would not have been the less certain; for the sea now flows within its walls, and overflows sites that were formerly inhab-

ited. Its submersion is plain and distinct. The rock upon which General Wolfe landed has nearly disappeared. The waves break against the south wall, which they have undermined and thrown down. . . . . . each succeeding tide flows freely into the northern side of the deserted city. The lands westward also bear testimony to an extensive submergence."

A year ago, having heard that Mr. K. McIntosh, of St. George's Channel, Cape Breton, had lately made a survey, the first accurate one ever made of the old town and its fortifications, and knowing that he was a man of exceptionally keen discernment, and withal a student of science, I obtained from him the statement which is here appended.

This statement I submitted to Major O. C. Williamson, R.A., who has made a critical study of fortification and the fads of each school and period, and he appended a few comments which accompany it. These, he would have extended, had he not been suddenly called to take command of a battery in India. However, coming from so good an authority, they may be regarded as convincing that the French engineers purposely built their foundations down to the level of low water; and therefore that the partial submergence now noticed is no evidence of subsidence subsequent to the building of the fortress.

There is still to be considered Dr. Gesner's paper as a whole. The statements accompanying those relating to Louisbourg treat of the general question regarding recent elevation and depression includihg the quarternary period. These remarks of his should be now read in the light of modern ideas on the changes that occurred during the glacial epoch, and the sharp distinction that has to be drawn between the movements of the land in relation to the sea as a base level, acting in a vertical direction, and wave erosion which makes a constant and destructive lateral advance on our coast. It is clear that Dr. Gesner did not carefully distinguish the actions of the several agents of a destructive character that have been at work on the shores and structures at Louisbourg, and it would seem he has imputed to the former changes that have been brought about by the denudation resulting from the latter agency alone.

So far as Louisbourg is concerned, I submit there is there no evidence of subsidence within historic times.

The Question of Subsidence at Louisbourg, Cape Breton.—By Kenneth McIntosh, C. E., *St. George's Channel, Richmond Co., N. S.*

(*Read 21st December, 1903.*)

Engaged during a portion of the year 1901 in making surveys on the site of the old fortress of Louisbourg, Cape Breton Co., N. S., I incidentslly took somewhat copious notes of topographical features, and although I made nothing in the nature of a contour survey, still I am satisfied that the result of my work is a plan, which, simply as a plan, is in some respects instructive.

During the current year, 1903, I received a letter from Dr. Henry S. Poole, on the reputed subsidence of land in the neighborhood of Louisbourg, and asking for my impressions on this question.

This being the first intimation I ever had that a recent subsidence of land in that region was regarded by anyone as a fact, I was under this disadvantage, viz., that my observations, although copious, were not made with a view to throwing light on this subject.

However, upon carefully scanning my notes taken on the ground, I find it difficult to surmise upon what observed facts the conclusion of subsidence could possibly be based.

In this connection, it will, of course, be understood that we are utterly waiving any discussion of the subsidences and elevations of the remote past, and that we are dealing with the hypothesis of a subsidence in present progress, and it is scarcely necessary to state that the question can only be decided, if at all, by a comparison of the present height above sea level of some portion of the shore which has neither been built nor worn away, with its elevation above tide level at some remote period.

I am of the opinion that there are some features of the fortifications at Louisbourg yet remaining, by which we can make a test of this point.

The peninsula upon which the fortress was situated has so frequently been described that I need not give any lengthened description of it, but it would appear necessary to note certain features of a topographical and geological character.

Extending from the historic White Point easterly to Black Rock, the whole shore is an alternation of beaches of rounded cobble-stones and of hard enduring rocky reefs, the remnants of redoubts belonging to an overpowered battle-front of the coast.

Inland along the same line there is an alternation of gravelly hills and low flat peat-covered swamps, almost wholly destitute of trees, and at a point nearly due south from the citadel of the fort there is a continuous stretch of swamp formed of peat of a depth varying from one to probably over six feet, and rising from an elevation but little above ordinary tide to a maximum height of twenty to thirty feet at the foot of the southern glacis.

Rochefort Point, the eastern extremity of the peninsula, is a rock about fifteen feet in height, thinly covered with soil, but from it along the harbour shore towards the west, bed rock, except in the sea ledges, disappears, and the northern portion of the ruined town and fortifications is evidently situated on a considerable depth of glacial drift, more of the nature of gravel than of clay.

On consulting a plan of Louisbourg,* dated 1745, by Lieutenant R. Gridley, of Pepperell's Artillery, we will observe a pond, with a beach of considerable extent, lying between it and the harbour. At the southeastern extremity of this pond was erected the Maurepas Bastion. It would be more correct to state that this bastion was built out in the pond, since the waters of the pond surround it on its front, its left flank, and its rear—and its

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* A copy of Gridley's plan is in the Provincial Museum, Halifax, N. S., and a reproduction of it in *Trans. Roy. Soc. of Canada*, vol. ix (1891), sec. 2, plate 4.

position is such that the beach to the north of the pond might well serve it as a glacis.

From the Maurepas Bastion towards the south, a wall, a moat, and another bastion—the Bourillon—completely covered the neck of the isthmus at this point.

Although any argument based on a comparison of the heights of the pond and of ordinary high tide, must necessarily be inconclusive as to the question of subsidence, still the hypothesis does not derive support from the fact that the bottom of the sluiceway, at the western extremity of the pond, is now sufficiently high to carry away the waters of the pond at all but abnormally high tides.

At present, however, a barrier of sand and stones lies across the point of exit, and the drainage of the pond is by filtration through the gravel of the beach, and this latter fact gives rise to some reflections of a general character.

In the case of ponds along the ocean shore, separated from the ocean by a beach, and into which no brook of any considerable volume empties itself, this percolation through the sand is sufficient in the ordinary case to prevent the waters of the pond from overflowing the beach. We have frequently observed cases of this kind. And it may, too, be observed, that in the case of any particular pond of this class, a certain fixed relation exists, under normal conditions, between the height of the water in the pond and the mean level of the ocean water outside.

The waters of the Bras d'Or Lake as compared with the Atlantic Ocean, although a regular channel connects them, are subject to this very law, and the stone structure at the St. Peter's canal locks is arranged with regard to this condition.

The reasons for this state of things are to my mind so plain that I do not consider it necessary to explain them.

I trust I am not making too long a step in the reasoning process here introduced if I state that any elevation of the Atlantic Ocean with reference to the Island of Cape Breton, or

better to illustrate our case, any depression of the Island of Cape Breton with reference to the ocean, would have the effect of correspondingly submerging islands and promontaries in Bras d'Or Lake, provided, of course, that the rivers flowed as before, and the channel connecting Bras d'Or Lake with the ocean did not have an increased or a decreased capacity. Briefly, granting the conditions above stated, the relation of waters as to height would remain the same as before, even supposing the mean height of the lake water was some feet above the mean height of the ocean water in the first instance.

Let us now apply this law to the case of the pond at Louisbourg. The flow of water into the pond is small, and cannot have changed for centuries; its present way of egress is, at any rate, not *more* free than when a sluice-way connected the pond with the Atlantic Ocean; consequently any subsidence of the general area must be accompanied by a corresponding submergence of all objects standing out in the pond. Yet if my memory does not deceive me, the gorge of the Maurepas Bastion presents the same little pond in the plan by Lieutenant Gridley, made in 1745, that my notes present in the year 1901 —there is no evidence of subsidence. We will now direct our attention to the neighborhood of the sluice-way, at the western extremity of the pond, and I will first state the facts as they appear: at this end of the pond, and extending for some distance along its northern shore, the land, instead of being a desert of sand and shingle as is the remainder of the beach, is covered with grass to the line of wave action, and there are still remaining, in its grassy swells, those characteristic zig-zags so puzzling to the unmilitary eye, and upon which French military engineers spent much thought one hundred and fifty years ago.

Carrying our investigations further towards the waters of the harbour we find a line of post-stubs, showing their ends above the rounded beach-rocks, and here, again, the characteristic zig-zag presents itself. Further investigation reveals the

fact that the intervals between posts were planked and walled with stones. If we have an unusually low tide, however, we can see a most interesting exposure. A structure of close-faced cribwork presents itself. I should prefer to call the structure cellular since the intersections of axe-hewn timber are at intervals of about three feet, and a ledge of concrete still remains in the beach overlying the timber structure.

The cribwork structure above referred to will be found to have two faces presented seaward forming an angle of about 125 degrees, and the apex of this angle is at present som what below the level of the lowest tide.

The lines of posts above referred to are continuations of these sides: and extending from the apex along the face of the structure towards the west is a row of piles of round timber driven as closely as possible to one another. This, in brief, is what remains of the "La Greve" or Beach Battery.

Turning again to the Atlantic coast we find a line of post-stubs similar to those existing at the site of the Beach Battery, lying between the Prince's Bastion and the sea, and continuing its zig-zags northerly towards the Bourillon Bastion, and for some distance southerly towards Black Rock: and opposite the extremity of the moat which fronts the Prince's Bastion are still to be seen in the beach the planks which formed the sluiceway by which the waters of the moat escaped into the Atlantic Ocean, and if the moat were in practical use today that sluiceway is sufficiently far above tide level to perform the service for which it was originally intended. Owing to the fact that the ground originally at the point referred to was quite low, and that the ground had evidently been taken from a distance to raise the glacis, it is obvious that there existed a necessity for leaving as *small a margin* as possible between the bottom of the sluiceway and *ordinary high tide* mark. [1] This, to my

(1) The Vaubon system of fortification used by the French, demanded a most pedantic and fixed proportion between heights and slopes of glacis and main work, so I suspect the moat was made at as low a level as possible There is a similar French moat at Mauritius where there has been no subsidence.—Major O. C. Williamson, R. A.

mind, leaves but a *very narrow margin* of possibility for the truth of the hypothesis of subsidence.

Let us now return to the Beach Battery, and here we can anticipate the questions: Why does that battery appear partially submerged today? Why should the French engineers build batteries out in the sea when there was sufficient dry land upon which to build them?

To the first question we can easily reply, that the fact that a row of ordinary piles was driven along its northern face has in it more than a mere suggestion that the structure was originally placed out in the water. There is the additional fact that the timbers which constitute the cribwork structure do not lie horizontally, but wherever they are exposed they are found to have a seaward slope corresponding closely to the slope of the sea floor upon which they rest. If placed on dry land these timbers would in all probability be placed horizontally.

But as synthetic reasoning demands an hypothesis capable of embracing all the observed facts, I would in answer to the second question invite your attention to the supposition that the Beach Battery was built to combat another foe (2) besides the British.

Reference to a present day plan of the harbour will show a conspicuous concavity in that portion of the beach lying southeasterly from the position of the battery and a prominence at the point where its remains are to be found which must strike the eye of the most casual observer.

These facts taken in concert with those already enumerated in this connection seem to justify the following retrospect:—The beach was gradually wearing away, and its drift caused by the eroding action of the ground-swell arising from easterly gales was constantly travelling along the shore towards the west. This must be stopped and the wisdom of the engineer who planned this structure has its monument in the fact

(2) In fact an ordinary "spur" for preventing denudation and not a fortification at all, in original intention at any rate.—Major O. C. Williamson, R. A.

that the grassy mounds raised on the shingly inner slope of the beach by the labor of man are today green, but are gradually wearing away as their artificial faithful protector yields to time and the warring elements.

In view of the considerations above stated it seems plain, to my mind, that the partial submergence of the Beach Battery today does not necessarily constitute an argument in behalf of subsidence.(3)

It seems to me not a partizan view of the case to say that the assertion that land on the eastern sea-board of Cape Breton had subsided, could much more easily go unchallenged were there no Louisbourg in the case with its ditches, its ruined curtain walls originally placed within easy reach of the ocean spray, and its batteries, as probable reference points to serve as data from which to judge of terrestial stability or change.

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(3) Such a "spur" would, if artificial, naturally subside in time.—Major O. C. Williamson, R. A.

Phenological Observations in Canada, 1903.—By A. H. MacKay, LL. D., F. R. S. C., *Halifax.*

(Read 9th May, 1904).

Observers etc. for the First Table, Canada, 1903.

Nova Scotia : The average of about 300 selected schedules.

Prince Edward Island : Mr. John MacSwain, Charlottetown.

New Brunswick : George U. Hay, D. Sc., F. R. S. C., Saint John ; J. Baxter, M. D., Chatham.

Quebec : Miss A. M. Dresser, Francois Xavier, Brompton, Richmond Co.: Miss J. M. Varney, Richmond, Richmond Co.

Ontario : Cephas Guillet, Ph.D., Ottawa ; Mr. A. B. Klugh, Guelph, Wellington Co.; Mrs. F. E. Webster, Creemore, Simcoe Co.; J. H. Elliott, M. B., Gravenhurst, Muskoka.

Assiniboia : Mr. Thos. K. Donnelly, Pheasant Forks.

Alberta : Mr. Percy B. Gregson, Blackfalds.

British Columbia : J. K. Henry, B. A., Vancouver.

The first table of phenochrons contains the observations of this staff of observers at the stations indicated, the observations being confined to the "time when first seen" except where indicated in a few cases.

Phenological Observations, Second Table, Nova Scotia, 1903.

The second table gives the phenochrons for each of the ten biological regions into which the Province of Nova Scotia has been provisionally subdivided, each phenochron being the average of a few or many observations within the region. Over 300 selected schedules of observations are represented in this summation.

The schedule of the school teachers who directed the observations at each school were sent in at the end of the school year to the Inspectors who transmitted them to the Superintendent of Education for the province, who in turn submitted them to the following staff for criticism, selection, and compilation into "belt" and "region" phenochrons. The

critical comments of each of this staff of phenologists were published in the April *Journal of Education*, 1904, pages 74 to 81, for the benefit of the observers for next year.

PHENOLOGICAL REGIONS AND COMPILERS, NOVA SCOTIA.

Region I. (Yarmouth and Digby Co.): Principal A. W. Horner, Yarmouth.

Region II. (Shelburne Co.): Principal C. Stanley Bruce, Shelburne.

Region II. (Queens Co.): Miss Minnie C. Hewitt, Science Teacher, Lunenburg Academy.

Region II. (Lunenburg Co.): Principal Burgess McKittrick, Lunenburg.

Region III. (Annapolis and Kings Co.): Principal Ernest Robinson, Kentville.

Region IV. (Hants Co.): J. E. Barteaux, Science Master, Truro Academy.

Region V. (Halifax and Guysboro Co.): Principal G. R. Marshall, Halifax.

Region VI. (Cum. and Col. on Cobequid Bay): J. E. Barteaux, Truro.

Region VII. (Cum. and Col., North slope): Principal E. J. Lay, Amherst.

Region VII. (Pictou and Antigonish Co.): W. P. Fraser, Science Master, Pictou Academy.

Region VIII. (Richmond Co.): Principal Geo. W. McKenzie, Sydney Mines.

Region VIII. (Cape Breton Co.): Loran A. DeWolfe, Science Master, North Sydney.

Region IX. (Victoria Co.): Loran A. DeWolfe, M. Sc., North Sydney.

Region X. (Inverness Co. sloping to Gulf): Loran A. DeWolfe.

The compilations of this staff were further reduced into the form published in the second table, "The Phenochrons of Nova Scotia, 1903," by Miss Jean Lindsay, B. A., Halifax. The phenochrons of the several divisions of the province, as well as the individual schedules are bound into annual volumes for preservation and the convenience of future phenological students.

In previous reports attention was called to the phenological work in other countries, especially that of Mr. Edward Hawley, F. R. Met. Soc., V. M. H., in England; of Dr. Ihne of Darmstadt, in Europe; and of the public school work of Michelsen and Mathiassen in Denmark, on Nova Scotian lines. Nothing strikingly new has appeared during the year abroad or at home in this department. The Marine Biological Station of Canada under the directorship of Professor Ramsay Wright of Toronto University, was working at Malpeque in Prince Edward Island during the year. Incidentally botanical work was done, more particularly the determination of the microscopic flora on which the oysters of the region feed. Mr. A. B. Klugh of the Wellington Field Naturalists' Club published valuable botanical papers during the season, and the Guelph *Herald* distinguished itself by the publication of an interesting series of botanical and other natural history articles and notes from members of the club. The *Ottawa Naturalist* had a specially valuable series of articles on Nature Study. The *Journal of Enucation* of Nova Scotia functions as the organ of the phenological observers of the province. The Bibliography of Canadian Botany for the year was presented to the Royal Society in a special report as usual.

The botanical nomenclature used is that of the latest edition of Gray's Manual, and the names of the birds are those of the American Ornithological Union.

The tables are also published in the proceedings of the Royal Society, as a part of the report of the Botanical Club of Canada.

[At the date this is going to press (Jan. 1906) it is satisfactory to see that the *annual* date instead of the *mensual* date is beginning to be used in Great Britain by Mr. Edward Mawley, F. R. Met. Soc., V. M. H., as can be seen in his valuable and interesting "Report on the Phenological Observations for 1904." The Nova Scotian system now used throughout Canada, and demonstrated to be so clear and space-saving in some of Mr. Mawley's tables, is undoubtedly the simplest system for the notation of dates and the recording and calculation of all phenochrons, individual, special and general. In Germany and Denmark a step has been taken in this direction by utilising the dates of the spring months for obtaining averages, means or "middle dates." But this method confines comparisons to different series of phenochrons for each month. The "annual" dates form a single series for the year; and after very little use become as full of meaning as the popular "day of the month," and very much more convenient for recording and averaging].

PHENOLOGICAL OBSERVATIONS, CANADA, 1903.

OBSERVATION STATIONS.

Number.	Day of the year 1903 corresponding to the last day of each month. Jan ..... 31 July ....212 Feb ..... 59 Aug ...242 March .. 90 Sept ..273 April ...120 Oct .....304 May ....151 Nov ... 334 June ....181 Dec 365	Average dates for Nova Scotia. †	Charlottetown, P. E. I.	St John, N. B.	Chatham, N. B.	Brompton, Que.	Richmond, Que.	Ottawa, Ont.	Guelph, Ont.	Creemore, Ont.	Gravenhurst, Ont.	Pheasant Forks, Assa.	Blackfalds, Alberta.	Vancouver, B. C.
1	Alnus incana, Willd	104	. ..	....	109	84	73	99	80	....	106	....	*119	....
2	Populus tremuloides	118	128	....	113	....	....	90	90	....	106	133	130	....
3	Epigæa repens, L..........	102	118	...	115	99	100	101	....	....	102	. ..	....	....
4	Equisetum arvense........	127	....	....	132	....	....	....	....	*110	121	..	138	90
5	Sanguinaria Canadensis	125	...	....	...	....	...	109	...	....	. .	...	....	...
6	Viola blanda	121	....		132	113	119	117	112	*132	107	....	....	....
7	Viola palmata, *cucullata* .	123	...	129	143	120	122	118	118	*119	116	....	140	...
8	Hepatica, triloba, etc	118	...	....	. .	...	93	88	90	89	79	. .	100	. ..
9	Acer rubrum	126	137	....	121	119	107	104	97	....	106	. .	....	96
10	Fragaria Virginiana	124	....	129	...	119	100	112	118	....	105	124	144	....
11	" " (fruit ripe)	163	...	....	179	148	151	150	158	....	....	178	170	....
12	Taraxacum officinale.....	126	142	....	141	119	116	109	90	*100	106	133	....	...
13	Erythronium Americanum	133	....	129	143	112	113	107	116	*100	104	....	....	....
14	Coptis trifolia..............	131	....	136	143	106	....	120	118		126	....	....	....
15	Claytonia Caroliniana.....	123	....	....	....	....	....	90	....	...	79	....	...	....
16	Nepeta Glechoma..........	140	....	....	....	....	....	*132	....	...	....	....	...	108
17	Amelanchier Canadensis .	140	....	136	135	...	...	119	129	*129	124	149	148	. .
18	" " (fruit ripe)	196	....	..	....	....	....	....	193	..	....	210	183	. . .
19	Prunus Pennsylvanica....	143	...	151	....	132	124	128	132	*134	127	...	144	120
20	" " (fruit ripe)	221	....	...	...	....	....	....	212	...	...	...	..	...
21	Vaccinum Can. and Penn.	141	....	145	143	....	....	119	120	..	122	....	...	...
22	" " (fruit ripe)	195	....	....	....	....	....	....	188	....	...	...	....	....
23	Ranunculus acris	148	....	....	136	141	132	136	136	....	140	119	166	...
24	R. repens	154	....	....	....	....	..:.	160	....	*132	...	...	....	....
25	Trillium erythrocarpum ..	147	...	136	143	134	116	*126	115	....	131	...	....	....
26	Rhododendron Rhodora .	145	....	145	...	....	....	....	....	....	....	...	...	....

* When becoming common.

† The phenochrons for Nova Scotia are the averages of over 300 selected schedules, the fractions being omitted. In some of the schedules from the Western Provinces of Canada, the cognate western species are taken as indicated exactly in previous reports.

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27	Cornus Canadensis..... ..	151	....	145	157	....	....	*140	143	....	146	...	....	...
28	" " (fruit ripe)	208	....	...	....	....	....	...	198	..	....	....	....	....
29	Trientalis Americana	150	...	151	157	119	150	135	144	....	144	...	...	....
30	Clintonia borealis	152	....	151	167	....	....	*142	135	....	144	....	....	...
31	Calla palustris	159	....	...	155	149	117	154	....	....	141	....	...	....
32	Cypripedium acaule	159	...	....	167	....	....	147	150	....	139	...	....	...
33	Sisyrinchium augustifol'm	160	....	....	179	139	119	138	...	..	158	....	166	....
34	Linnæa borealis	167	....	....	172	118	....	149	149	....	154	...	...	....
35	Kalmia glauca	150	....	....	162	..	....	147	....	....	131	....	....	....
36	Kalmia angustifolia	168	....	...	179	....	....	161	..	....	..	....	.. .	....
37	Cratægus Oxyacantha ...	161	162	...	....	...	...	....	....	....	144	....	..	....
38	Cratægus coccinea, etc....	156	...	..	...	....	....	129	...	. ..	....	....	....	....
39	Iris versicolor...	170	...	....	....	...	...	155	....	..	157	....	...	...
40	Chrysanthemum Leucan.	166	....	....	....	....	....	*156	....	...	149	...	...	....
41	Nuphar advena...........	163	....	....	....	....	...	142	....	....	158	....	...	...
42	Rubus strigosus..........	164	....	....	....	...	...	141	145	*156	141	173	....	....
43	" " (fruit ripe)	214	....	....	....	...	..	....	186	....	....	210	...	...
44	Rhinanthus Crista-galli . .	171	....	..	...	...	...	....	...	....	....	. .	....	...
45	Rubus villosus	166	....	...	171	....	...	148	149	*161	141	....	..	126
46	" " (fruit ripe)	241	....	..	....	....	....	....	206	...	....	...	....	...
47	Sarracenia purpurea	144	..	....	....	....	....	*161	144	...	....	...	..	...
48	Brunella vulgaris.........	172	....	....	179	....	....	159	154	...	153	...	..	....
49	Rosa lucida..............	178	....	....	....	...	153	145	....	....	166	165	164	162
50	Leontodon autumnale ..	168	..	....	160	....	....	....	....	....	....	....	....	....
51	Linaria vulgaris	168	....	...	....	....	....	161	...	...	. .	....	....	....
52	Trees appear green........	138	...	....	....	....	....	129	134	132	....	....	....	....
53	Ribes rubrum (cultivated)	142		....	....	...	....	.. .	...	*131	. ..	....	....	....

* When becoming common.

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PHENOLOGICAL OBSERVATIONS, CANADA, 1903.

Observation Stations.

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54	Ribes rubrum (fruit ripe)	199		...	....	....	....	189	....	....	...	210	...	....
55	R. nigrum, (cultivated) ..	134	....	.. .	....	...	..	....	....	....	....	...	....	....
56	" (fruit ripe)	210	....	....	....	...	...	193	....	*182	....	....	...	....
57	Prunus Cerasus	147	160	...	. .	132	....	....	....	*130	....	....	....	109
58	" " (fruit ripe)	205	....	....	....	...	....	...	....		...	.	...	....
59	Prunus domestica	151	....	...	....	129	128	...	....	*130	....	....	....	....
60	Pyrus malus	151	157	....	....	136	131	131	....	*132	...	....	....	117
61	Syringa vulgaris	162	166	....	158	142	139	134	...	*141	....	....	....	130
62	Trifolium repens	162	....	....	...	....	149	139	....	....	143	....	164	133
63	Trifolium pratense	160	....	....	....	149	141	139	....	....	147	....	....	139
64	Phleum pratense	174	....	....	....	...	...	....	....	....	....	.. .	....	....
65	Solanum tuberosum	182	...	....	....	....	169	....	....	*184	....	..	....	....
66	Ploughing (first of season)	113	....	....	....	121	80	89	....	91	....	....	93	....
67	Sowing, "	123	127	....	....	129	117	104	...	105	....	103	96	....
68	Potato-planting "	123	....	....	....	145	120	142	....	138	....	127	115	....
69	Sheep-shearing "	129	....	..	....	139	....	....	....	....	....	152	166	....
70	Hay-cutting "	200	. ..	..	....	...	. .	. ..	....	....	....	199	220	....
71	Grain-cutting "	246	239	....	..	....	....	205	....	....	....	246	228	...
72	Potato-digging "	266	..	....	..	....	....	278	....	274	....	265	220	....
73a	Opening of rivers "	71	88	....	....	..	75	....	....	67	....	....	105	....
73b	Opening of lakes "	89	....	....	....	...	83	....	..	....	....	....	128	....
74a	Last snow to whiten gr'nd	116	....	...	115	95	113	94	...	84	...	119	140	....
74b	" to fly in air	130	....	....	115	121	113	111	....	86	....	....	140	...
75a	Last spring frost—hard ..	140	146	....	101	152	..	122	...	....	....	161	142	....
75b	" " —hoar..	158	....	....	....	....	....	124	....	....	....	162	142	....
76a	Water in streams—high ..	89	....	....	....	....	79	....	....	79	...	247	223	....
76b	" " —low ..	193	....	...	....	....	158	....	....	....	....	..	312	. .

* When becoming common.

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77a	First autumn frost—hoar..	257	....	....	....	...	....	283	....	....	....	....	245	....
77b	" " —hard..	284	....	..	...	.. .	...	....	....	....	..	....	312	....
78a	First snow to fly in air ...	290	...	....	....	....	296	281	....	....	....	252	255	....
78b	" whiten ground	3'6	351	....	....	....	331	330	....	299	...	255	255	....
79a	Closing of lakes	339	....	....	....	....	335		....	....	....	....	320	....
79b	" rivers	344	351	....	...	.. .	340	....	....	...	....	....	320	....
81a	Wild Ducks migrating, N.	85	...	....	90	54	61	....	91	....	....	100	93	....
81b	" " S.	302	...	....	....	....	286	....	....	....	....	...	....	....
82a	Wild Geese migrating, N.	78	75	....	71	....	66	100	86	....	....	98	93	....
82b	" " S.	318	246	..	...	....	285	...	...	....	..	310	...	....
83	Melospiza fasciata, North.	84	87	....	100	....	110	78	63	73	....	...	....	....
84	Turdus migratorius "	78	85	....	79	65	65	75	70	60	...	103	110	....
85	Junco hiemalis "	81	96	....	86	56	...	78	Res	....	....	...	...	....
86	Actitis macularia "	131	...	....	147	....	....	122	127	130	...	....	....	....
87	Sturnella magna "	121	....	....	....	....	...	101	76	131	....	96	....	....
88	Ceryle Alcyon "	125	....	....	128	115	....	117	99	115	....	151	. ..	....
89	Dendrœca coronata "	137	....	...	141	....	109		122	....	...	..	....	...
90	D. æstiva "	138	....		146	....	....	130	124	....	....	...	.. .	....
91	Zonotrichia alba "	116	....	....	126	....	...	119	109	....	....	...	....	....
92	Trochilus colubris "	147	....	....	151	....	....	....	140	...	....	....	....	....
93	Tyranus Carolinensis "	136	....	...	140	....	....	141	121	131	. .	119	....	....
94	Dolychonyx oryzivorus "	136	....	....	147	138	137	141	128	....	....	....	....	...
95	Spinis tristis "	145	....	..	145	....	...	115	Res	129	....	....	....	....
96	Setophaga ruticilla "	133	....	..	148	..	....	135	129	....	....	....	....	....
97	Ampelis cedrorum "	144	..	....	159	....	. .	....	130	....	. .	107	....	....
98	Chordeiles Virginianus "	128	164	....	152	....	..	141	140	..	...	148	....	....
99	First piping of frogs	100	119	. ..	111	99	82	78	73	....	....	105	112	....
100	First appearance of snakes	100	....	.. .	....	115	84	85	78	....	....	109	....	....

† The phenochrons for Nova Scotia are the averages of over 300 selected schedules, the fractions being omitted. In some of the schedules from the Western Provinces of Canada, the cognate western species are taken as indicated exactly in previous reports.

NOVA SCOTIA PHENOCHRONS, 1903.

FLOWERING AND OTHER PHENOCHRONS FOR EACH REGION OF THE PROVINCE OF NOVA SCOTIA, COMPILED FROM 300 PUBLIC SCHOOL OBSERVATION SCHEDULES.

[*The Phenochrons for each region, (which are the averages of many observations), have the fractions omitted.*]

YEAR ENDED JULY, 1903, NOVA SCOTIA.

Day of the year corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec	365

When First Seen. Regions. 1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope, (Inv. and Victoria).	10. Inverness Slope to Gulf.	Average for Province.	Number.	Nova Scotia.	When Becoming Common. Average for Province.	1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope, (Inv. and Victoria).	10. Inverness Slope to Gulf.
99	91	90	99	115	122	105	112	...	101	104.3	1	Alnus incana, Willd	114.2	106	102	104	115	127	129	112	121	...	108
....	110	103	128	130	129	115	125	....	119	118.8	2	Populus tremuloides	121.4	95	116	112	134	130	127	124	130	.. .	123
186	87	91	100	103	116	108	113	115	112	102.3	3	Epigæa repens, L.	111.6	99	98	104	110	113	114	116	119	119	119
118	113	121	130	131	138	126	145	129	121	127.5	4	Equisetum arvense	135.4	130	125	131	136	140	148	133	150	132	125
. ..	115	...	135	....	125	123	....	....	128	125.3	5	Sanguinaria Canadensis	136.5	..	128	....	159	....	130	129	..	..	136
107	114	118	122	121	119	125	130	128	125	121.3	6	Viola blanda	127.9	118	121	125	129	130	127	131	136	131	129
112	118	120	123	126	122	127	133	130	131	123.3	7	Viola palmata, cucullata	131.6	123	125	127	130	132	128	133	140	137	137
111	115	....	126	.. .	....	120	...	....	..	118 2	8	Hepatica triloba, etc	125.4	123	121	....	133	....	....	124	....	....	....
118	116	121	121	123	123	125	140	141	129	126.2	9	Acer rubrum	131.8	125	124	130	129	132	130	132	146	....	135
113	117	118	122	124	122	126	132	128	130	123.6	10	Fragaria Virginiana	132.8	124	126	126	133	134	131	135	140	136	139
149	155	155	160	165	158	164	177	172	171	163.	11	" " fruit ripe	173.6	162	167	169	173	178	171	177	182	176	178
112	118	123	124	127	127	129	134	130	132	126.1	12	Taraxacum officinale	134.	123	125	130	132	134	134	137	143	138	139
134	150	133	131	....	127	127	. .	131	..	133.5	13	Erythronium Americanum	138.9	142	154	139	138	. ..	132	134	...	131	....
120	125	129	131	132	131	133	134	138	137	131 2	14	Coptis trifolia	137.	128	131	137	136	138	137	140	140	141	140
101	. ..	121	129	125	119	126	139	....	126	123.5	15	Claytonia Caroliniana	128.2	113	....	126	134	127	122	133	141	....	128
140	124	139	131	140	139	140	156	151	.	140.4	16	Nepeta Glechoma	148.6	155	134	146	139	148	145	146	163	159	....
135	131	132	135	139	139	139	153	152	146	140 5	17	Amelanchier Canadensis	145.1	139	136	138	142	144	142	145	157	155	150
199	197	192	202	....	....	194	....	...	....	196.9	18	" " fruit ripe	206.9	210	207	....	209	....	....	201	....	....	....

132	136	138	141	145	139	143	156	152	152	143.8	19	Prunus Pennsylvania	149.4	139	141	142	147	151	143	148	162	162	155
248	201	....	212	....	...	214	....	....	230	221.2	20	" " fruit ripe	228.6	253	210	..	222	..	.	221	....	....	236
129	129	138	139	139	139	145	149	159	149	141.7	21	Vaccinium Can. and Penn	149.1	136	136	146	147	146	147	150	159	166	154
179	19	181	177		179	199	246	....	213	195.8	22	" " fruit ripe	221.4	220	206	...	...	..	....	205	253	....	222
134	139	139	145	149	147	149	163	157	158	148.4	23	Ranunculus acris	154.6	143	147	149	153	147	155	157	166	161	166
141	143	151	154	152	157	158	168	....	163	154.5	24	R. repens	161.	148	149	157	163	161	157	165	173	...	173
140	144	143	144	150	143	146	159		156	147.5	25	Trill. erythrocarpum	154.1	147	151	150	150	159	150	153	165	..	159
138	136	140	145	142	148	146	160	155	152	145.4	26	Rhododendron Rhodora	153.2	147	143	143	152	151	155	152	165	160	157
138	144	149	148	148	151	149	163	159	163	151.5	27	Cornus Canadensis	158.7	146	150	157	157	157	157	157	167	168	168
232	199	....	232	166	....	....	..	....	213	208.5	28	" " fruit ripe	220.	239	208	233	239	183	..	...	...	....	218
140	141	142	147	149	152	149	161	160	160	150.5	29	Trientalis Americana	156.7	146	148	148	154	157	154	155	170	167	165
145	148	143	155	160	150	156	169	....	148	152.9	30	Clintonia borealis	158.7	154	154	152	159	166	153	162	175	...	152
...	168	..	160	...	169	150	...	...	150	159.5	31	Calla palustris	164.8	....	174	...	....	..	171	158	...	...	156
149	149	152	158	161	156	157	173	164	....	159.	32	Cypripedium acaule	164.2	156	154	158	166	168	161	167	177	168	....
146	149	154	156	163	158	160	171	171	171	160.3	33	Sisyrinchium angustifolium	166.7	157	156	159	163	171	164	166	176	173	177
156	155	158	161	166	170	169	173	183	178	167	34	Linnæa borealis	171.1	161	161	166	169	174	172	175	178	....	181
141	143	149	142	152	151	155	...	156	162	150.4	35	Kalmia glauca	157.3	147	150	156	146	154	159	159	174	158	166
150	161	166	174	161	177	174	166	...	183	168.2	36	Kalmia angustifolia	174.	156	168	172	179	170	180	180	170	...	188
164	153	153	157	164	161	164	169	....	166	161.4	37	Cratægus oxyacantha	166.5	166	158	163	161	171	169	169	171	....	169
155	153	153	157	....	154	158	...	..	170	157.4	38	Cratægus coccinea, etc	163.	158	155	159	165	.	165	164	....		172
158	162	166	170	168	169	169	178	179	180	170.3	39	Iris versicolor	175.7	165	169	174	176	176	175	173	182	183	182
154	161	162	163	160	161	163	178	180	180	166.6	40	Chrysanthemum Leucanthemum	174.7	166	168	171	173	177	170	172	182	184	183
171	155	167	165	171	156	171	....	165	151	163.9	41	Nuphar advena	170.8	175	166	171	174	173	167	175	183	....	153
159	157	157	161	163	161	160	179	172	168	164.	42	Rubus strigosus	170.9	163	162	171	169	174	164	170	184	.	178
199	207	207	219	...	232	201	238	....	209	214.2	43	" fruit ripe	222.9	212	213	218	225	....	239	209	244	....	222
163	167	171	177	175	....	178	....	....	..	171.9	44	Rhinanthus Crista-galli	176.5	174	174	177	180	171	...	181	....	..	
159	160	167	168	163	154	171	173	177	174	166.9	45	Rubus villosus	173.3	168	167	175	173	170	161	178	180	180	178
235	229	229	240	...	263	240	256	....	237	241.3	46	" fruit ripe	249.8	236	243	237	253	..	273	252	262	..	241
161	167	164	167	168	166	170	156	....		144.9	47	Sarracenia purpurea	171.3	172	173	171	167	172	171	176	167	..	
164	168	173	173	..	180	176	....	....	169	172.2	48	Brunella vulgaris	176.	173	174	180	177	....	147	180	....	...	170
177	175	179	179	179	173	179	..	....	185	178.6	49	Rosa lucida	183.4	184	182	185	178	..	179	185	...	..	189
162	163	166	166	173	166	169	....	....	181	168.5	50	Leontodon autumnale	174.7	173	173	174	175	174	170	174	....	...	182
149	195	....	158	...	168	169	....	...	....	168.	51	Linaria vulgaris	183.2	....	230	....	..	....	190	176	....	...	.
129	135	132	139	138	134	140	154	145	..	138.7	52	Trees appear green	152.2	142	140	161	153	154	141	155	167	155	....
131	133	138	142	141	143	142	154	154	147	142.8	53	Ribes rubrum (cultivated)	148.8	137	138	145	147	149	149	148	159	161	151
187	186	184	195	....	....	199	239	....	207	199.75	54	" " (fruit ripe)	216.7	217	202	....	214	....	....	206	246	....	215
134	136	140	143	142	143	144	155	158	146	134.4	55	R. nigrum (cultivated)	150.8	149	141	149	148	149	147	149	158	161	151
...	199	...	210	.	..	193	237	...	211	210.	56	" (fruit ripe)	219.9	....	201	....	217	....	..	..	242		219
133	137	138	144	150	147	148	162	158	153	147.5	57	Prunus Cerasus	153.	138	143	145	151	159	154	154	164	162	158
....	189	....	186	..	....	205	....	..	221	205.4	58	" " fruit ripe	200.	....	201	...	170	...	....	...	...	..	228
136	137	140	146	153	150	149	170	170	156	151.	59	Prunus domestica	157.6	143	143	146	155	160	157	155	175	177	161
139	140	142	148	154	150	150	170	163	158	151.8	60	Pyrus Malus	159.6	147	147	157	160	164	155	157	175	172	164
151	151	154	158	167	160	160	177	169	172	162.1	61	Syringa vulgaris	168.1	158	156	159	166	174	166	165	180	177	176
147	155	157	157	162	162	161	172	174	169	162.	62	Trifolium repens	168.9	158	161	164	164	171	168	169	179	176	175
140	148	155	156	158	163	161	175	174	172	160.8	63	Trifolium pratense	167.7	151	156	165	166	168	171	170	180	....	178
177	167	171	169	166	173	172	...	....	199	174.7	64	Phleum pratense	178.6	176	171	167	178	171	183	175	179	...	205
174	174	180	182	....	....	182	....	....	200	182.3	65	Solanum tuberosum	190.	183	190	182	....	....	....	...	....	....	205

NOVA SCOTIA PHENOCHRONS, 1903.—(*Continued*).

Year ended July, 1903, Nova Scotia.

Day of the year corresponding to the last day of the month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec	365

When First Seen. — Regions.

Number	Year ended July, 1903, Nova Scotia.	1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8 Richmond and Cape Breton.	9. Bras d'Or slope (Inv. and Victoria).	10. Inverness Slope to Gulf.	Average for Province.
66	Ploughing (first ef season)	92	105	111	119	113	114	123	118	117	118	113.2
67	Sowing " "	111	116	118	124	121	123	128	131	141	130	123.9
68	Potato-planting (first of season)	107	114	118	128	120	129	129	124	129	130	123.2
69	Sheep-Shearing (first of season)	122	123	125	134	131	141	135	128	126	123	129.3
70	Hay-cutting "	182	188	180	213	212	201	205	213	....	209	200.5
71	Grain-cutting "	246	234	236	246	249	255	238	251	....	250	246.1
72	Potato-digging "	242	259	260	269	272	265	269	277	274	270	266.1
73a	Opening of rivers	62	66	72	58	81	69	65	88	65	85	71.4
73b	Opening of lakes	67	76	81	86	92	92	96	104	101	95	89.2
74a	Last snow to whiten ground	105	103	105	117	121	113	120	109	134	129	116.
74b	" to fly in air	107	110	108	132	135	129	139	145	156	142	130.7
75a	Last Spring frost—hard	140	127	138	149	131	150	147	144	135	136	140.2
75b	" " hoar	147	151	158	172	151	155	161	157	163	164	158.1
76a	Water in streams—high	93	98	97	230	....	86	65	....	99	88	89.8
76b	" " low	151	154	248	175	..	156	220	250	....	191	193.3
77a	First Autumn frost—hoar	255	256	254	261	259	255	262	271	....	242	257.6
77b	" " hard	290	289	287	284	288	267	280	287	.	285	281.3
78a	First snow to fly in air	297	309	281	285	295	282	280	297	291	286	290.6
78b	" whiten ground	327	327	303	309	303	290	289	315	299	304	306.9
79a	Closing of lakes	342	339	357	319	335		339	342	....	343	339.8
79b	" rivers	349	343	....	348	345	340	344	314	....	344	314.7
81a	Wild ducks migrating, N	72	78	79	81	78	79	79	125	95	89	85.9

When Becoming Common. — Regions.

Number	Year ended July, 1903, Nova Scotia.	Average for Province.	1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col, Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria)	10. Inverness Slope to Gulf.
66	Ploughing (first ef season)	124.	110	117	128	...	124	....	130	126	127	127
67	Sowing " "	134.	123	123	131	....	134	....	136	141	144	138
68	Potato-planting (first of season)	129.9	118	123	130	...	130	....	137	131	133	135
69	Sheep-Shearing (first of season)	139.7	134	132	137	....	148	....	149	139	144	133
70	Hay-cutting "	210.	199	199	202	. .	219	....	211	223	....	216
71	Grain-cutting "	253.1	255	246	250	...	262	....	247	255	....	255
72	Potato-digging "	275.8	264	270	274	...	275	...	279	285	277	281
73a	Opening of rivers	....	..	....	....	....	....	....	...	....	....	....
73b	Opening of lakes	......	..	....	....	....	....	....	..	....	....	....
74a	Last snow to whiten ground	..	...	....	....	....	....	....	...	....	....	....
74b	" to fly in air	......	...	....	....	...	....	....	. .	....	....	....
75a	Last Spring frost—hard	.....	..	....	....	....	....	....	....	....	....	....
75b	" " hoar	.....	...	....	..	..	...	....	....	....	..	....
76a	Water in streams—high	......	...	...	...	...	...	...	....	....	...	...
76b	" " low	......	...	..	...	....	....	...	...	...	...	...
77a	First Autumn frost—hoar	.....	..	...	...	....	....	....	....	..	...	...
77b	" " hard	......	...	...	...	....	....	...	....	...	. .	...
78a	First snow to fly in air	......	...	....	...	....	....	....	....	..	....	....
78b	" whiten ground	......	...	....	..	....	....	...	..	....	.	....
79a	Closing of lakes	......	...	...	...	..	....	...	....	..	.	....
79b	" rivers	....	..	...	...	....	....	....	...	....	...	....
81a	Wild ducks migrating, N	.....	....	....	...	...	...	....	.. .	....	....	...

251	310	...	287	....	323	296	320	....	353	302.9	81b	Wild ducks migrating, S.											
75	79	77	80	71	82	74	77	81	81	78.3	82a	Wild geese migrating, N.											
291	324	321	314	333	338	308	330	274	315	318.1	82b	" " S											
73	76	76	86	82	94	97	85	83	85	84.0	83	Melospiza fasciata, North											
76	75	72	74	71	83	77	89	84	83	78.7	84	Turdus migratorius "											
74	82	78	76	90	76	81	81	....	85	81.0	85	Junco hiemalis "											
....	118	....	140	122	130	130	....	138	139	131.3	86	Actitis macularia "											
....	111	114	129	124	110	116	..	...	133	121.1	87	Sturnella magna "											
116	122	118	129	112	141	121	129	128	134	125.2	88	Ceryle Alcyon "											
....	109	140	135	156	135	138	148	....	138	137.5	89	Dendrœca coronata "											
136	139	141	137	135	140	139	134	..	139	138.1	90	D. æstiva "											
125	118	99	126	....	111	103	126	....	123	116.4	91	Zonotrichia alba "											
146	148	146	146	145	151	147	....	....	146	147.3	92	Trochilus colubris "											
....	130	141	133	134	124	140	146	....	139	136.2	93	Tyrannus Carolinensis, North											
150	128	144	131	142	141	138	133	....	120	136.5	94	Dolychonyx oryzivorus "											
....	142	115	148	142	159	144	151	.. .	132	145.7	95	Spinis tristis "											
137	144	....	140	....	88	156	....	....	....	133.3	96	Setophaga ruticilla "											
152	150	141	145	...	145	140	....	.. .	136	144.2	97	Ampelis cedrorum "											
146	128	119	110	131	131	151	....	122	118	128.6	98	Chordeiles Virginianus "											
85	82	91	94	99	121	97	112	104	111	100.	99	First piping of frogs											
99	96	103	111	112	113	112	119	118	114	110.1	100	First appearance, snakes											

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1902.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATON STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.	Province of Nova Scotia. YEAR 1902.
182^{2}	.....	.....	.....	182	.....	.....	182	.....	.....	182^{4}
183^{6}	183^{2}	183^{9}	183^{19}	183^{12}	.....	183^{13}	183^{6}	.....	183^{3}	183^{70}
.....	.....	.....	184	.....	.....	184	.....	.....	.....	184^{2}
.....	.....	.....	.....	.....	.....	185	.....	.....	.....	185
.....	.....	.....	.....	.....	.....	187	.....	.....	187	187^{2}
.....	188^{3}	.....	.....	.....	.....	188	.....	.....	.....	188^{4}
.....	189	.....	.....	189	.....	189^{2}	189	.....	189	189^{6}
.....	.....	.....	.....	.....	.....	190	.....	.....	.....	190
.....	.....	.....	192	.....	.....	191	.....	.....	.....	191 192
.....	.....	.....	.....	.....	.....	.....	.....	.....	195	195
.....	.....	.....	196	.....	.....	.....	.....	.....	196	196
.....	.....	.....	.....	.....	.....	.....	.....	.....	197^{2}	197^{2}
198	198^{2}	.....	.....	.....	.....	198	.....	.....	.....	198^{4}
.....	.....	.....	.....	.....	.....	202	.....	.....	.....	202
.....	203	.....	.....	.....	.....	.....	.....	.....	203	203
.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	204
.....	.....	204	.....	.....	.....	205	.....	.....	.....	205
209	.....	209	.....	.....	.....	.....	.....	.....	.....	209^{2}
.....	.....	.....	.....	.....	.....	.....	.....	.....	213	213
215	.....	.....	.....	.....	.....	.....	.....	215	.....	215^{2}
.....	216	216	.....	.....	.....	216^{3}	.....	.....	.....	216^{5}
.....	217	.....	.....	.....	.....	.....	.....	.....	.....	217
.....	218	.....	.....	.....	.....	218	.....	.....	.....	218^{2}
.....	.....	.....	.....	.....	.....	219	.....	.....	.....	.....
220	.....	220	.....	.....	.....	220^{2}	220	.....	.....	220^{5}
221	.....	.....	.....	.....	.....	221^{2}	.....	.....	221^{2}	221^{5}
.....	.....	.....	.....	.....	.....	.....	.....	.....	224^{2}	224^{2}
.....	.....	.....	.....	.....	.....	225^{2}	.....	.....	225	225^{3}
.....	.....	.....	.....	.....	.....	227^{2}	226	.....	227^{2}	226 227^{4}
.....	228^{2}	.....	.....	.....	.....	228	228	.....	228^{2}	228^{6}
234	.....	.....	.....	235^{3}	.....	235	.....	.....	235	234 235^{5}
.....	.....	.....	.....	.....	.....	237	238	.....	.....	237 238
.....	239	.....	239	239^{2}	.....	239^{2}	.....	.....	239	239^{7}

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS.—(*Continued*).

OBSERVATION STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.	Province of Nova Scotia. YEAR 1902.
.....	245	.....	.....	245	.....	245^{2}	.....	.....	245	245^{4} 246
.....	.....	.....	.....	.....	249	250^{2}	.....	.....	.....	249 250^{2}
.....	....	.....	.....	.....	.....	.....	.....	.....	251^{2} 253	251^{2} 253
.....	.....	.....	.....	.....	.....	259	...	.....	256	256 259
264	.....	.....	.....	.....	270	....	.....	.....	....	264 270
.....	.....	271	.....	....	271	.....	....	.....	.....	271^{2} 275^{2}
.....	278	....	279	275	275	.....	.....	.....	277	277 278 279
.....	.....	..	....	.....	.....	280^{7}	.....	.....	.....	280^{7}
.....	.....	.....	281^{11}	281^{3}	281	281^{42}	281^{5}	281	281^{7}	281^{70} 282^{3}
.....	284	282	.....	.....	283	282	282	.....	....	283 284
285	285^{2}	.....	.....	287	.....	.....	....	.....	.....	285^{3} 287
.....	291	.....	.....	.....	.....	.....	.....	....	.....	291
292^{9}	292^{20}	292^{4}	292	.....	.....	292^{3}	.....	....	.....	292^{37}
293^{10}	293^{35}	293^{7}	293^{8}	293	293^{2}	293^{4}	293	.....	293	293^{69}
294	294	.....	.....	.....	294	294	.....	.....	.....	294^{4}
.....	297	297^{2}	.....	.....	.....	297	.....	.....	.....	297^{4}
298^{4}	298^{25}	298^{2}	.....	....	.....	....	298	....	.....	298^{32} 299
299	299^{3}	.....	.....	.....	.....	301^{2}	....	.....	300	300 301^{2}
303	302	.....	303	302 303	.....	.....	....	.....	....	302^{2} 303^{3}
304^{4}	304^{5}	.....	.....	.....	.....	304	.....	.....	.....	304^{10}
.....	307	.....	.....	.....	.....	.....	.....	.....	.....	307
308	.....	.....	.....	.....	.....	.....	.....	.....	.....	308
.....	.....	.....	314	.....	.....	.....	.....	.....	.....	314
.....	326	.....	.....	.....	.....	.....	.....	.....	.....	326
.....	.....	332	.....		.....	.....	.....	.....	.....	332

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1903.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION STATIONS.

Province of Nova Scotia. YEAR 1903.	1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.
21	21	....	....	....	....	....	....	....	....	....
22	22	....	....	....	..	....	....	....	....	....
30^{5}	....	....	....	....	....	....	....	30^{3}	....	30^{2}
....	....	....	....	....	....	....	....	....	....	....
36^{6}	....	....	....	....	....	....	36^{6}	....	....	....
....	....	....	....	....	....	....	....	....	....	....
59	....	....	....	....	....	....	59	....	....	....
86^{2}	....	86^{2}	....	....	....	....	....	....	....	....
88^{2}	....	88	....	....	....	....	88	....	....	....
91	91	....	....	....	....	....	....	....	....	....
93	93	....	....	....	....	....	....	....	....	....
95	95	....	....	....	....	....	....	....	....	....
97	97	....	....	....	....	....	....	....	....	....
100^{2}	....	....	....	....	....	....	102^{2}	....	....	....
111	....	....	....	....	111	....	....	....	....	....
114^{2}	....	114	....	....	....	....	....	....	114	....
115^{43}	....	115^{34}	115^{9}	....	....	....	....	....	....	....
116^{3}	....	116^{2}	116	....	....	....	....	....	....	....
121^{3}	....	....	....	....	....	121	121^{2}	....	....	....
124^{3}	124	124	....	124	....	....	....	....	....	....
132	....	....	....	....	....	....	132	....	....	....
133^{2}	....	....	133	....	....	....	133	....	....	....
134^{2}	134	....	134	....	....	....	....	....	....	....
135^{29}	135^{4}	135^{22}	135	....	....	....	135	135	....	....
137^{2}	137	....	....	....	....	....	....	....	....	137
138^{9}	138	138^{6}	138^{2}	....	....	....	....	....	....	....
139^{19}	139^{2}	139^{10}	139^{5}	139	....	....	139	....	....	....
140^{77}	140^{10}	140^{43}	140^{5}	140^{4}	140^{10}	....	140^{5}	....	....	....
141^{81}	141^{8}	141^{19}	141^{2}	141^{5}	141^{10}	141^{2}	141^{28}	141^{3}	141	141^{3}
142^{115}	142^{3}	142^{26}	142^{8}	142^{9}	142^{16}	142^{2}	142^{31}	142^{11}	142^{2}	142^{7}
143^{7}	....	143^{2}	.	....	....	....	143^{3}	143	....	143
144	....	144	....	....	....	....	....	....	....	....
145	....	145	145	....	....	....	....	....	....	....
147^{2}	....	147	....	....	....	....	....	....	....	..
148^{3}	....	....	148^{2}	....	....	....	148	....	....	....
149^{5}	149^{3}	149	....	....	....	....	149	....	....	....

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS.—(*Continued*).

OBSERVATION STATIONS.

Province of Nova Scotia. YEAR 1903.	1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.
156	....	....	....	....	....	....	....	. .	....	156
159	. ..	159	....	....	159	....	159	....	....	....
160^{46}	160^{8}	160^{27}	160^{2}	160	160^{5}	....	160^{3}	....	....	....
161^{17}	161^{8}	161^{4}	....	161^{2}	....	....	161^{3}	....	....	....
162^{2}	.. .	162	....	162	....	....	....	....	....	....
165^{2}	....	...	165	165	....	.. .	....	....	....	....
166	....	....	166	. ..	....	....	....	....	....	....
167^{7}										
169	....	167^{7}	....	169	....	....	....	....	....	....
170										
171	. .	..	....	171	....	....	170	....	....	....
172	....	....	....	172	....	....	....	....	....	....
173	....	.. .	.. .	173	....	....	....	....	....	....
174^{3}	....	....	....	....	....	174	174	....	174	....
175^{5}	....	175	....	175	....	175	175	175	....	....
176^{152}	176^{13}	176^{48}	176^{18}	176^{20}	176^{14}	176^{4}	176^{26}	176^{4}	176^{2}	176^{3}
177^{27}	....	177	....	177	177^{5}	....	177^{6}	177^{8}	177	177^{5}
178^{37}	....	178	....	178^{5}	178^{5}	....	178^{12}	178^{8}	178^{2}	178^{4}
179^{6}	....	....	....	179	....	....	....	179^{3}	179^{2}	....
180	....	....	....	...	....	....	180	... .	....	....
181^{4}	181^{2}	....	....	181	....	....	181	.. .	....	....
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BOTANICAL NOTES IN NOVA SCOTIA.—BY A. H. MACKAY, LL. D.

(Read 18th May, 1903).

Apios Apios (L.) MacM. Ground Nut.—Found by W. H. Prest in Queens county.

Crataegus Robinsoni Sargent. Robinson's Hawthorn.—A new species found in Pictou county. Named after Mr. C. B. Robinson, late Science Master in Pictou Academy. First collected by one of his botanical students, Miss Isabella W. MacCabe.

Calluna vulgaris (L.) Salisb. Heather.—Spreading in Pt. Pleasant Park, Halifax. Transplanted to Park at Saint John, N. B., where it is growing. In the Public Gardens, Halifax. Found by C. B. Robinson on the 23rd of March, 1903, at Bay View, near entrance of Pictou harbor, "about 300 yards from cemetery, a short distance from the road, and 20 yards from N. W. corner of brackish water beyond Sea View (Bay View) Cemetery, on Pictou Road, near a little brook." Found previously near Pictou Landing, opposite side of the harbor to Pictou town.

Andromeda Polifolia (L.)—Found by Mr. A. W. Fraser near Sherbrooke, N. S. Also found near Halifax.

Gratiola aurea Muhl. Goldenpert.—Found on the sandy margins of Lake Annis, Yarmouth county, by Dr. David Soloan.

Gerardia paupercula (A. Gray) Britton. Small-flowered Gerardia.—Found by Dr. Soloan on the margin of Lake Annis, Yarmouth county.

Lappula Lappula (L.) Karst. European Stickseed.—Found at Fairview, Halifax county, by Mr. John MacAloney.

Razoumofskya pusilla (Peck) Kuntze. Small Mistletoe.—C. B. Robinson of Pictou, in 1903, made the following report on this species:—

"During the summer of 1902 Mr. Clifton D. Howe, of the University of Chicago, discovered the Dwarf Mistletoe, *Razoumofskya pusilla,* parasitic upon *Picea Mariana,* at Bay View, near Pictou. Subsequent search in that district has shown that although it is rare on the whole, it grows in great abundance between Pictou Landing and Rustico, upon trees of every size; but of the one species (Black Spruce) over fifty infected trees were counted."

Cypripedium reginæ Walt. Showy Ladies' Slipper. And *C. hirsutum* Mill., Large Ladies' Slipper.—Reported from north Cape Breton (Inverness county) by Mr. Finlayson to Mr. C. B. Robinson.

Smilax rotundifolia (L.). Greenbrier.—Found by Dr. Soloan near lakes Annis and Brazil, Yarmouth county.

Iris Pseudacorus (L.) Yellow Flag.—Found at Arcadia, Yarmouth county, by Miss Kelsey of Yarmouth.

Veratrum viride Ait. American White Hellebore.—Found in west Halifax county by the late Mrs. Dominey, teacher.

Dryopteris Lonchitis (L.) Kuntze.—At Aspy Bay, C. B., by A. H. MacKay, 1876. At River Dennys Cave, C. B., by C. B. Robinson, 30th July, 1902.

Asplenium viride Huds.—At the Falls, Moose River, Cumberland Co., about 1890. At River Denys' Cave, C. B., by C. B. Robinson, 30th July, 1902.

Woodwardia Virginica (L.) J. E. Smith.—At North West Arm, Halifax, by Harris, before 1876. Near lakes, Halifax, Richard Power, 1900. At Cheverie, Hants Co., by Miss K. E. MacKay, 1902; determined by C. B. Robinson.

Stypocaulon scoparium (L.) Kutz.—A marine alga. First found in America by Dr. Howe at Pictou, and afterwards by Mr. C. B. Robinson at Cape John (23rd April, 1903), and afterwards at Pictou, Pictou Island, and at Pugwash, Nova Scotia; and on the Prince Edward Island coast opposite.

TERATOLOGICAL SPECIMENS.

Ranunculus acris (L.). The Tall Buttercup.—Misses Curren and James presented a specimen from the Musquodoboit Valley, Halifax county, in which a number of stalks were united into a flat stem nearly an inch broad, with a number of flowers sessile on the top. The branches and leaves belonging to this flattened stem were peculiarly dwarfed.

Taraxacum Taraxacum (L.) Karst. Common Dandelion.—Several scapes nearly a foot long were united completely into a flat band like a scape nearly an inch in width, the whole surmounted by a crowded buch of heads sessile on the united first scape. Halifax county.

Chrysanthemum Leucanthemum (L.). Ox-eye Daisy.—Several stems apparently all united into an enlarged fluted and inflated stem which was surmounted by a crowded bunch of sessile heads. The leaves arising from the stem were peculiarly dwarfed. Queens Co., W. H. Prest.

Iris versicolor (L.).—What appears to be a white mutation or variety of the Common Blue Flag was discovered near Guysboro county. Several specimens were found near the Lochaber Lake by Mrs. M. W. Andrews of Isaac's Harbor, roots of some were taken up to be cultivated under observation.

THE STRUCTURE AND SUCCESSION AT NORTH SYDNEY AND SYDNEY MINES, C. B.—BY LORAN A. DEWOLFE, M. A., *North Sydney.*

(*Read 14th March, 1904*)

CONTENTS.

INTRODUCTION.

Origin of paper.—The following paper is extracted from a thesis accepted in part fulfillment of the requirement for the degree of Master of Arts at Dalhousie University in 1903. The field work was done during the autumn of 1902 and the folllowing winter; and it and the preparation of the results have been conducted under the general direction of Dr. J. E. Woodman, who also assisted in revising the manuscript for the press.

[Contributions from the Science Laboratories of Dalhousie University ; Geology and Mineralogy.]

(Communicated by Dr. Woodman).

Location of field.—The territory covered by the study lies along the northwest side of Sydney harbor. It extends from the mouth of Leitch's creek on the west, through North Sydney and Sydney Mines on the east, to Cranberry Head; thence northwest along the shore of Spanish bay to the entrance of Big pond; thence southwest to Sawmill lake, and to the Intercolonial railway track where it crosses. It thus embraces roughly an area ten miles by two.

General stratigraphy.—The strata belong wholly to the Carboniferous period; lying on the northwest side of an anticline of these rocks which runs northeast from the pre-Cambrian of George's river end of the Coxheath hills, and plunges northeast as well.

This fold dies out in Sydney harbor; and its strata on the north leg change as one goes eastward, from a normal northeast gradually to an east-west and finally a northwest strike. At the extreme east side of the extension of the fold, there arises an imperfect synclinal basin, containing the coal seams of Sydney Mines, and freeing the strike of the beds from any influence of the anticline.

From the west end of the field studied, and beyond, eastward one and one-half miles to Limestone creek, the strata have been considered as belonging to the Lower Carboniferous limestone, equivalent to the Windsor series of Fletcher, on the mainland. From Limestone creek to Stubbart point, about six miles, has heretofore been mapped as Millstone Grit [vide Brown; also Geol. Surv. Can., No. 653, Sydney sheet, 134]. The boundary between this and the overlying Coal Measures, which extend thence eastward to the ocean at Cranberry Head, about four miles, is very arbitrary as it has been defined up to the present.

Topography.—The surface of the land presents little marked topographic variation. That underlain by the Windsor series is low for the most part. While the same series on the peninsula to the south, lying between the two arms of Sydney

harbor, shows sinkhole topography and blind streams, there are none here. The Millstone Grit section is undulating but in general more elevated than the others. In some places it rises sharply from the harbor to a height of one hundred and eighty feet, and its average elevation is about one hundred. Between Sawmill lake and Limestone creek, at an elevation of one hundred and thirty feet, two square miles are covered with swamp and bog. Although low land occurs on all sides in adjacent territory, the ground here remains wet throughout the year.

In the Coal Measures the average elevation is approximately eighty feet. Owing, however, to the much greater exposure to marine action, the shore cliffs are higher than farther west.

Special interest attaches to the topography of the land north and northwest of Cranberry Head. From Black point the surface slopes down to Big pond. The shores of this body, beside which the Nova Scotia Steel and Coal Company have built their furnaces, are low and in some places even swampy. On the north side of the pond is the new colliery (Sydney No. 3). Stretching down to the shore on the east is a level bog, covering about three square miles. This swamp evidently was once the bed of a post-glacial lake, in all probability somewhat above sea level. A shore section of the bog shows that it rests in part, at least, upon bedrock. How much the shore has been cut back by wave action at this point, and where the initial shoreline of subsidence stood, it is impossible to say. But the bed of the lake, then probably filled up as now by vegetation, was brought practically to sea-level; and in three places the cross-section of the bog is exposed to marine erosion. Headlands on either side of the swamp have also suffered rapid loss by this agency. But where the erosion is most rapid—at Cranberry Head and Black point—the cliffs are lowering; for the land as a whole slopes inland and toward the bog rather than seaward.

Here, then, was formerly a lake, surrounded by gently sloping glacial debris, which itself lies for the most part as a thin mantle upon the bedrock. It was of irregular outline, with at least three coves on three of its sides. These now reach to the shore line, and the sea occupies what was once their ends. The three coves are represented by (1) the sections exposed on the shore between Black point and Cranberry Head; (2) the shore of Big pond; and (3), the deepest, at Lloyd's cove, to which the sea at times has access.

An additional ten or fifteen feet would have admitted the sea to the whole of this lake basin. In that event, Cranberry Head and Black point would stand out as islands.

Shoreline phenomena.—According to the classification of Dr. F. P. Gulliver, the shore as a whole is in an adolescent stage of development, following depression. Proof of this depression hardly need be stated in detail—the presence of estuaries like Sydney harbor itself may be accepted as sufficient evidence. It may be said, parenthetically, that no positive data have been gathered showing recent elevation here.

The adolescence is shown by the forelands of Allen point and Jackson point, by South bar on the Sydney side of the harbor, by bay bars at Lloyd's cove and Big pond, and by shore swamps near Limestone creek. Finally, the rapid wearing away of the cliffs shows that maturity has not been reached. Indeed, the mouth of the harbor is still in a somewhat earlier stage in its cycle than the shore nearer the head of the estuary.

Glaciation.—The whole of the field has been glaciated, and the topography reflects in a general way a pre-glacial relief, subdued by filling up hollows and planing down eminences. The general evenness of resistance is shown by the scarcity of inland outcrops.

Striations are rare, because of the post-glacial weathering of the surface wherever unprotected by soil. At upper North

Sydney they strike N. 38° E., and are crossed by later ones running N. 58° E. One mile to the west, striae run N. 40° E. The drift itself does not show by its contours the direction of ice motion; but at upper North Sydney the surface is profusely covered with granite boulders, whose source may have been anywhere between north and southwest of this spot.

Glacial origin must be ascribed also, in part, to Sydney harbor. The upper part of Southwest Arm is deeper than the seaward part, or than the main harbor; and apparently shows a true fjord character. The channel of this arm is from fifty-four to sixty feet deep, while the main mouth of the harbor is only forty. Not until one passes the mouth of the harbor and reaches the open water of Spanish bay is depth found equal to the deeper parts within the arm. The channel of what may conveniently be called the old Sydney river, continues for four or five miles out to sea, deeper than the general bottom. While this may indicate only submergence of a normal river valley, it may also have resulted in part from gouging, as part of Southwest Arm evidently has originated.

Throughout the field, small lakes are abundant. Sawmill, or Pottle's, with an area of about five square miles, is the largest. The lakes all have a longer diameter northeast and southwest, parallel with the harbor front, and with the general direction of the glacial striae in the district. This attitude, taken with other evidence, such as the location of lakes along contacts of strata, appears to point to a glacial origin. About a mile east of Pottle's lake is a small pond and bog, called Ferris lake. It is connected with the former by a strip of swamp about 300 feet wide, probably at an earlier time part of a lake or brook bed. Ferris lake itself is in most parts but four or five feet deep, and over most of its extent is merely a wet bog. The whole area is about one square mile, of which water occupies scarcely 300 square yards. Some of the lakes are

kettle holes, while others may be due to an unequal distribution of drift, creating new lines of drainage or diverting old ones.

References.—The following papers and books have been used in preparing this paper:—

Brown, Richard.

'71. The coal fields of Cape Breton.

Dawson, Sir J. W.

'78. Acadian Geology, 3rd ed.

Fletcher, Hugh.

:00. The Sydney coal fields [pamphlet, Geol. Surv. Can., accompanying three revised geological sheets.]

Gilpin, Edwin, Jr.

'86. Cape Breton Carboniferous. Nov. Scot. Inst. Nat. Sci., proc. and trans., vi, pp. 289-298.

'88. Ditto. vii, pp. 24-25, 100-117.

'89. Ditto vii, pp. 214-226.

Robb, Charles.

'74. Report on explorations and surveys in Cape Breton, Nova Scotia. Geol. Surv. Can., rep. for 1873-74, pp. 171-188.

'76. Ditto, rep. for 1874-75, pp. 166-266.

Part 1. Descriptive Geology.

LIMESTONE SERIES.

Classes of rocks.—The study resulting in the present paper ended on the west arbitrarily at the railroad track, from the necessity of establishing an end somewhere. Thus the whole of the limestone series did not come into the field. The strata observed, however, can be conveniently grouped into three classes: —(1) a very calcareous shale; (2) a much less calcareous sandstone; (3) beds of marl and impure limestone, containing large

but very variable amounts of lime. The shale, digested in HCl. leaves an insoluble residue of clay amounting to about 75%. The sandstone contains from 75% to 90% silica. The marl leaves a much smaller residue than the shale.

Inland observations.—These rocks are all exposed in a railway cutting immediately south of Limestone brook. They lie conformably, showing good contacts between the sandstones and calcareous shales, and dip 30° N. The sandstone here breaks into large flags suitable for building purposes. Ripple marks exposed on the under surface, wherever the underlying shale has fallen away, show wind from the south. At another horizon, a mile away, markings show an east wind.

The direction of dip here is important, as well as the amount, which is greater than in the Coal Measures to the east. The strata are under the immediate influence of the granitic core of the Boisdale hills to the southwest.

From this cut downward along Limestone brook, the ground is low and swampy, and gives no outcrops. On Fletcher's recent map (:00) this brook is given as the boundary line between the lower series and the Millstone Grit, except for about half a mile where limestone is given on both sides. Finding no exposures, I am unable to verify his conclusions. At the mouth of the brook, however, the contact is at least two hundred feet southwest of its stated position, for grit is exposed throughout that distance. The map also indicates fossils near the bank of the brook, nearly a mile from its source. I was unable to find there any exposures of bedrock; but a large slab of drift sandstone contains some fossils.

Section along shore.—For about a mile eastward from the mouth of Leitch's creek, the banks are low and give no cliffs; but the glacial debris is shallow, and the rock frequently outcrops on the beach. These exposures show a calcareous sandstone with a laminated shaly structure, the rock crumbling

easily. It is possible that these strata alternate with concealed limestones and marls, as farther east.

Eastward toward the top of the series the cliffs become higher and more continuous. Beds of calcareous sandstone, calcareous red and green marl, and gray compact limestone alternate rapidly. The sandstone varies in compactness and texture, some breaking into slabs of several square feet, but scarcely one-fourth to one-half inch thick, while others form large cubical or rhombohedral blocks. The last varieties are especially well mottled with streaks and lenses of carbonaceous matter, so regularly arranged as to give considerable relief to the usual monotony of color in the cliffs. All the sandstones are red or brown, except a six-inch bed of hard gray rock, almost a quartzite, which overlies one of the gray limestone strata. Some of the flagstones are well ripple-marked, the wind having come from the east, and contain fine worm-like trails, too indistinct to ascribe to any particular origin. Rain-prints are also exposed on these beds. The weathering is often irregular, in one instance the softer black carbonaceous matter having entirely disappeared, leaving a skeleton rock.

The calcareous marl exhibits all degrees of cohesion between clay and shale. A bed of gypsum lies between two of marl; and the overlying stratum of the three is practically all clay, and contains a few small bedded stringers of fibrous gypsum, each about one-fourth inch thick. The limestone is of a slate-gray color, compact in texture, but not gritty.

Succession.—A section of this formation is more difficult to get than of either of the others. The lower part consists of about 200 feet of laminated, shaly, micaceous sandstone, with a considerable proportion of lime. In some parts the rock may fairly be called a limestone. Above this a nearly continuous

section of 179 feet in vertical thickness, beginning at the bottom and ending with the Millstone Grit, is as follows:—

red shale	2 ft.	
gray limestone	2	
gray, hard sandstone	—	6 inches.
mottled brown calcareous sandstone	20	
red calcareous marl	10	
gypsum	8	
clay marl with gypsum stringers	10	
limestone	2	
marl	8	
thin bedded flaggy red sandstone	20	
marl	10	
brown rippled sandstone	20	
green marl	8	
flaggy sandstone	15	
limestone and marl	12	
mottled sandstone	20	
ironstone	12	
	179 ft.	6 inches.

Ironstone contact beds.—The last twelve feet of the limestone formation consists of a hard and somewhat felspathic rock, light flesh in color, and containing a variable quantity of hematite. The corresponding rocks on the opposite side of the harbor contain more iron. The surface of the exposures softens and crumbles to a depth of half an inch.

No topographic change marks the contact of the two formations. The exact contact is, indeed, concealed. On the map sheet of the geological Survey of Canada (Sydney sheet, 134), Limestone brook is regarded as the dividing line; but at its mouth it is well into the Millstone Grit. Here Limestone creek, the tidal portion of the brook, makes in for about 200 feet with a depth of eight to ten feet, after which it shoals to two or three feet and swings westerly, almost parallel with the harbor. This brings the mouth of the brook proper about 800 feet from harbor front.

"MILLSTONE GRIT."

Succession.—For want of data based upon sufficiently wide field study, the various formations are retained in this paper as designed by Fletcher's map (Geol Surv. Can., Sydney sheet, 134), even though the reasons for delimiting them in precisely that way are not clear. Within the so-called "Millstone Grit," the succession upward is as follows, ending on the east at Stubbert's point:—

coarse grit and conglomerate	500	feet.
measures hidden	200	
conglomerate	5	
fine laminated sandstone	10	
conglomerate	30	
sandstone	10	
conglomerate	2	
sandstone and arenaceous shale	115	
measures hidden	1,000	
sandstone	400	
arenaceous shale	30	
conglomerate	5	
sandstone	300	
measures hidden	900	
coarse sandstone, in part a breccia	200	
underclay	2	
coal (Ingraham seam)	2	
shale and sandstone	41	
red marl	3	
conglomerate	8	
coarse sandstone	280	
fine "	100	
arenaceous shale	6	
sandstone	60	
	4,209	ft.

Conglomerates.—At the base of this formation, the texture is on the average slightly coarser than is the case higher up. Some strata grade into finer or coarser beds, but in most in-

stances the contact is an abrupt one. Not far above the base, a few strata of mixed conglomerate and breccia have been found, interbedded with fine sandstone. The rocks at this point are very ferruginous, in some spots sending out small streams of rusty water. The pebbles are almost entirely quartz. Sharp angular pieces and rounded pebbles occur together, such as one often finds upon the beaches of to-day. There is usually a sharp line of demarkation between the conglomerates and sandstones, showing that the conditions of deposition changed somewhat abruptly. The mixture of angular and rounded pebbles suggests the proximity of a cliff at the time of deposition.

It is difficult to determine the thickness of the conglomerate, as only parts of the beds are exposed, but the best estimate possible gives thirty feet as the total.

Coal.—Throughout the whole upper half of the formation coal seams occur, ranging from one-fourth to two inches in thickness.

About 386 feet below the base of the Coal Measures is a bed of shale, the first encountered in the Millstone Grit. It contains both arenaceous and argillaceous varieties, and a thin layer of red marl. The lower shale grades upward into sandstone, and this again into shale, twenty-five feet thick. At the base of this shale lies the Ingraham seam of coal, which, however, is not exposed on the sea cliff. I am informed by old residents that this coal measured two feet, and was worked many years ago for local supply. It has long since been abandoned. A section of the associated beds at this horizon would be as follows, in ascending order:—

underclay	2	feet.
coal (Ingraham seam)	2	
arenaceous shale	6	
sandstone	10	
arenaceous shale	15	
argillaceous shale	10	
red marl	3	
coarse gritty sandstone and conglomerate		

The total thickness of shale here amounts, then, to thirty-six feet. This "Ingraham seam" is not to be confused with the "Ingraham mine", to be mentioned later.

A new occurrence of coal has recently been reported. Mr. John Redmond, Upper North Sydney, while boring for a well on his farm, struck what is reported to be a two-foot seam. The land is under lease by Rev. Father MacPherson, of Little Bras D'Or. His brother informs me that the new discovery consisted of two feet of good coal, which with shale, clay, etc., makes a belt of six feet. No openings have been made, so that no information can be given at first-hand. If the occurrence is real, it is noteworthy as showing coal at a greater distance below the Coal Measures than has heretofore been recorded in this part of the Sydney basin.

Fossils.—Vegetable remains occur at many horizons, the most abundant being Calamites. None have been found erect. Indistinct remains of Sigillaria are also numerous. In a few places may be seen a net-work of leaves, sticks, etc., irregularly washed together; but none distinct enough to show structure. Impressions of large stems more than a foot in diameter occur, but so nearly obliterated as to leave only a coating of rust, without any detail of the original form.

Variation in dip.—Throughout this formation the dip changes considerably. At Limestone creek it is about 40° N.; but eastward along the shore it becomes less, the average for three miles being about 12°, and turns eastward. In the vicinity of North Sydney and from there to Cranberry Head the dip is northeast, becoming constantly less until in the Coal Measures it is only 6°.

Back from the shore there are few exposures, most of those found being in railway cuts. As these are not far from the water, their dips are the same as in corresponding cliff exposures. On Fletcher's map an outcrop is recorded as being

near the railroad, one mile east of North Sydney Junction, with a dip 25° E. There appears to be no bedrock here; but a large boulder was found, thrust up above the ordinary level, and its strata in the attitude described.

A dip section, to be accurate, would run northeast and southwest, with a curve southward in the western part.

COAL MEASURES.

Contact strata.—Although the boundary between the two formations have been placed at Stubbart point in maps heretofore published, there are many strata of coarse sandstone above it, and several small coal seams below. The sandstones, are, however, not so massive as those in the lower group, and the however, not so massive as those in the lower group, and the coal seams outcropping on the coast are unimportant as regards thickness and amount. The boundary has been placed, then, where a change occurs from beds prevailingly arenaceous to beds prevailingly argillaceous; and while its exact position may be a matter of debate, its general location may be regarded as established.

From the shore at Stubbart point the contact follows a more or less arbitrary line northwest to Little Bras D'Or lake. It is roughly traceable by a line of large sandstone boulders which are scattered in profusion over the ground, and whose presence has been attributed to the greater wearing away of the softer argillaceous rocks of the Coal Measures, and the consequent breaking down of the harder and topographically higher Millstone Grit. Conclusions here, however, must be based largely upon conjecture, as no exposures are to be found inland. On the geological map of the Survey (No. 134) the boundary curves considerably. This, and the curving of the coal seams, would be due largely to the basin-like structure, but also in part to topographic differences. Since the beds dip northeast at a low angle, rising ground would extend horizon outcrops noticeably to the southwest. The surface rises rather suddenly from

the harbor, and slopes from the divide gradually toward Big pond, thus giving to the eroded edges of rock horizons a crescent shape.

Divergence of outcrops.—The separation of horizons at the surface is noticeable from the harbor to Big pond. This is due in part at least, to the differences in dip. On Sydney harbor the dip is six degrees, while at Big pond and Black point it averages four to five. This difference in beds so nearly flat cannot but have some influence upon the location of the outcrops of two horizons between which lies a constant thickness of rock. The same condition obtains south of the harbor, at Victoria mines and southeastward.

Succession.—Beginning at the lowest strata, on the east side of Stubbart point, and going northeastward to the highest rocks at Cranberry Head, the order is as follows:—

	ft.	in.
arenaceous shale	20	
marl and clay, with small coal seams	20	
underclay	2	
coal	—	10
sandstone	20	
shale	25	
coal (Stony seam; contains 6 inches of rock)	3	
shale	10	
sandstone	12	
shale	4	
sandstone	3	
shale	6	
impure limestone	—	6
red marl	10	
shale	30	
coal	—	6
shale	2	
sandstone	8	
coal	1	
argillaceous shale	20	

	ft.	in.
sandstone	2	
argillaceous shale	25	
marl	15	
arenaceous shale	5	
sandstone	15	
arenaceous shale	5	
measures hidden	20	
bituminous shale and coal, (Indian Cove seam)	5	
shale	4	
sandstone	15	
arenaceous shale	15	
limestone	3	
shale and red marl	6	
sandstone	2	
shale and red marl	17	
shale	2	
shale and red marl	12	
massive sandstone	20	
clay and shale	6	
coal	1	3
argillaceous shale	2	
sandstone	15	
arenaceous shale	6	
clay	2	
coal	—	8
argillaceous shale	2	
sandstone	26	
argillaceous shale	5	
arenaceous shale	26	
argillaceous shale and marl	36	
coal	—	10
shale	—	6
sandstone	25	
arenaceous shale	25	
argillaceous shale	15	
arenaceous shale	2	
argillaceous shale	2	
sandstone	2	

	ft.	in.
argillaceous shale	4	
limestone	—	8
sandstone	3	
argillaceous shale	15	
limestone	—	4
red marl	2	
green marl	5	
red arenaceous shale	6	
arenaceous shale	20	
sandstone	6	
marl	6	
clay	2	
coal	—	4
clay and shale	1	3
coal	1	
shale	8	
sandstone	6	
arenaceous shale	5	
sandstone	6	
argillaceous shale (erect trees and many plant remains)	6	
clay	2	
coal (Sydney Main seam)	6	
marl	15	
sandstone	20	
arenaceous shale	3	
sandstone	8	
shale	8	
limestone	2	6
marl and clay	3	
bituminous shale (with *Naiadites*)	—	2
argillaceous shale	17	
bituminous shale (with *Naiadites*)	—	1·5
argillaceous shale	6	
sandstone	6	
argillaceous shale	15	
sandstone	15	
red marl	2	
shale	15	

	ft.	in.
coal (with calcareous underclay)	—	4
shale	3	
limestone	1	
shale	3	
limestone	2	
shale	26	
marl	4	
coarse sandstone	26	
shale (with erect *Calamites*)	15	
limestone	—	4
shale	1	
blue sandstone	20	
arenaceous shale	4	
limestone	—	4
red marl	2	
arenaceous shale	3	
sandstone	15	
arenaceous shale	15	
argillaceous shale and red marl	26	
shale and underclay (*Stigmaria*)	2	
coal	—	2
shale	4	
sandstone	4	
shale	4	
coal	—	2
shale	26	
sandstone	8	
clay	—	3
coal	—	3
shale	2	
coal	—	3
shale	1	6
coal	—	2
clay	—	2
coal	1	4
shale	4	
sandstone (quarry)	24	
shale and fire-clay	3	
coal	—	9

	ft.	in.
clay	—	3
coal	—	1
shale	6	
sandstone	24	
shale	20	
clay	—	6
coal	—	3
shale and underclay	5	
coal	—	4
shale	—	5
coal	—	7
sandstone	25	
clay	1	
coal	1	
strata mostly concealed	215	
argillaceous shale	20	
arenaceous shale	6	
argillaceous shale	10	
coal (Lloyd's Cove seam)	6	
blue marl	10	
arenaceous shale	2	
sandstone	5	
shale and underclay	1	
coal	—	6
black shale	—	6
coal	—	2
blue marl	8	
arenaceous shale	10	
blue marl	2	
coarse conglomeratic grit } Swivel	6	
sandstone } point	12	
sulphurous marl (upper ten inches almost red ochre)	6	
argillaceous shale (thinning out laterally into sandstone)	20	
gray fine sandstone	20	
red marl	2	
blue marl	5	
red marl	2	

	ft.	in.
limestone	5	
red marl	1	
argillaceous shale	50	
arenaceous shale	10	
argillaceous shale	5	
red marl	6	
blue marl	5	
red marl	10	
argillaceous shale	20	
sandstone	4	
arenaceous shale	5	
argillaceous shale	15	
red marl	5	
argillaceous shale	3	
clay	2	
coal (lower seam, Cranberry Head)......	1	
argillaceous shale	3	
sandstone	5	
argillaceous shale	11	
underclay	1	
coal (upper seam, Cranberry Head)	3	6
shale (to top of Cranberry Head).......	15	
	1,735 ft. 6in.	

Details of shore section.—Stubbart point stself is a salient of cross-bedded sandstone, which has been able to withstand marine action better than the shales overlying it and outcropping to the east of the point. Passing to the Stony seam, 88 feet above, the cliff was so covered with talus at the time of this study, that I was unable to examine the coal. Robb ('74) says that it has a fossiliferous limestone base. If so, this is the lowest occurrence within the Coal Measures, and none is known in the Millstone Grit.

The two next overlying seams, one six and the other twelve inches thick, are separated by sandstone which contains a number of Sigillaria trunks, six to eight feet in length. The sandstone grades laterally into shale, and thins out so that the coal

beds converge, but they do not meet within the limits of the section.

Indian Cove seam.—About eighty feet of strata, in part concealed, separate the last named seam from the Indian Cove seam. This is four feet thick, has a micaceous underclay, and a bituminous shale roof. The roof is calcareous and fossiliferous, containing large numbers of shells of Cytherea. The seam is worked by the Sydney Coal company, under the name of the "Greener mine." The coal contains a large amount of pyrite, which has decomposed near the outcrop. The rusty water from the opening on the shore is rapidly cementing the beach material into a conglomerate. On the Big pond end of the same seam is the long abandoned Ingraham mine, which was worked nearly thirty years ago for local use. In the old trenches remaining from this early work, a considerable quantity of iron has been deposited, resembling ordinary bog iron in appearance.

Section to Lloyd's cove.—Above the Indian Cove seam, there is a continuous rock cliff almost to Lloyd's cove, a distance of about two miles, and representing a vertical stratigraphical height of 1125 feet, including 215 feet largely concealed, on the east end. The argillaceous and arenaceous layers alternate rather regularly, and contain a few thin limestones. The approximate proportion of each is :—sandstone 316 feet, shale 534 feet, marl 36 feet, limestone 10 feet, bituminous shale $3\frac{1}{2}$ inches, coal 16 feet, concealed 215 feet.

To show the relative arrangement of these beds, a condensed section of this part of the field may be of interest. Sandstone, shale and marl are here grouped under the general term "strata." Indian Cove seam, with its fossiliferous roof containing Cytherea, etc., has been described. Above this the section is as follows :

	ft.	in.
strata	34	
limestone	3	
strata	65	
coal	1	3
strata	27	
coal	—	8
strata	90	
coal	—	10
strata	75	
limestone	—	8
strata	18	
limestone	—	4
strata	47	
coal	—	4
strata	1	3
coal	1	
strata (with erect trees)	33	
coal (Sydney Main seam)	6	
strata	54	
limestone	2	6
strata	3	
bituminous shale (with *Naiadites*)	—	2
strata	17	
bituminous shale (with *Naiadites*)	—	1.5
strata	59	
coal (with calcareous underclay)	—	4
strata	3	
limestone	1	
strata	3	
limestone	2	
strata (with erect *Calamites*)	71	
limestone	—	4
strata	25	
limestone	—	4
strata	63	
coal	—	2
strata	12	
coal	—	2
strata	29	3
coal	—	3

	ft.	in.
underclay	2	
coal	—	3
shale and underclay	1	6
coal } Chapel point	—	2
clay } Chapel point	—	2
coal } Chapel point	1	4
strata	28	
fireclay	3	
coal } Chapel point, upper seam	—	9
clay } Chapel point, upper seam	—	3
coal } Chapel point, upper seam	—	1
strata	50	6
coal	—	3
underclay and shale	5	
coal	—	4
shale	—	5
coal	—	7
sandstone	25	
clay	1	
coal	1	
concealed measures, of Lloyd's cove	250	

In this section there are eight beds of limestone, with a total thickness of ten feet, and nineteen coal seams with a total thickness of fifteen feet. Every seam possesses its underclay except one or two very thin layers; and Stigmaria rootlets abound. Hence it can scarcely be doubted that these seams for the most part have accumulated from vegetation in place. The term "strata," as used above, includes a few beds of underclay with rootlets, but containing no accompanying seam, showing that in some cases the vegetable matter was prevented from accumulating.

All the limestone layers are very similar in character, except the eight-inch one between the Indian Cove and Main seams. This is very compact and semi-crystalline, and of a brownish gray color. The others are coarse and bluish gray, somewhat crystalline and frequently brecciated. All rest upon shale,

while all except one have shale or marl immediately overlying. In the exceptional case, sandstone is above limestone.

Fossils.—The strata next below the Main seam give the best illustrations of erect tree trunks, of any on this coast. There Sigillaria from one to three feet in diameter show eight to ten feet of their length through beds of sand and shale. I found none with roots attached, but in one case the trunk is easily traced into the shale overlying a seam. The trees visible in these beds taper rapidly. The original bark forms a thin layer of glossy coal, the interior being filled with shale or fine sandstone.

Fern-like leaves and petioles are abundant in the sandstone surrounding the erect trees, lying with so little distortion that they must have fallen into still water or soft mud, and have been buried before they became disarranged. In several cases, leaves appear in the inferior layers, but no branches; and in higher strata branches are found. The rising sediment may have killed the tree gradually, leaving it at last shorn of its leaves, but with branches intact. These fell later into sediment newer than that which had received the leaves. The time came, however, when the dead top fell also, and was borne away; for now the truncated bole stands with overlying masses of rock which contain no trace of the missing wood.

While the sediment must have accumulated comparatively rapidly, to bury trees before they could decay and fall, it did not prevent other trees from taking root and growing to a considerable size. For erect trees are found in the same cliff at but slightly different levels. They were probably swift growers, but perhaps tenaceous of life and slow to decay. These qualities would readily explain the conditions under which we now find them. That the bark decayed more slowly than the wood is evident from finding the former carbonized, while the space once occupied by the latter is now filled with sandstone, or less commonly clay or shale.

In all this section, sand beds are replaced laterally by shales, or thin out into them. The clay must have accumulated until the water was comparatively shallow, then sand spread over it, thinning out as depth increased. After this had gone on for some time, the sea bottom was depressed and into the deepening water only mud could be brought. The clay overspreading the sand and extending beyond it enclosed a wedge of sand similar in shape and situation to those now exposed.

Main seam.—This seam is not well exposed in the cliff, so that information concerning it had to be gained from the mines. It is six feet thick, overlain by soft flaggy gray shale containing particularly good plant remains. The following are especially abundant:—Neuropteris cordata, Cyclopteris acadiana, Pecopteris, Alethopteris, and leaves of Cordaites.

Details of section to Cranberry Head.—Fifty feet above the Main seam lies a limestone horizon two and one-half feet thick, and crystalline. Three feet of marl and shale separate it from two inches of black bituminous shale, containing a multitude of fish scales and shells of Naiadites. Twelve feet above is a second similar layer, in which the shells compose nearly the whole mass. The species represented are Naiadites elongatus and N. laevis. They are supposed to be proof of brackish water or lagoon conditions.

The shell beds are succeeded by shale with a little sandstone to a depth of fifty feet, which in turn is followed by four inches of coal with a calcareous underclay. Three feet above the coal lies one foot of limestone. The underclay could not have got its lime from washings from this bed, for in that case, the intervening shale would also be calcareous. This is not the case ; consequently the underclay must have accumulated its lime independent of the bed above.

From this level to the top of the visible layers at Cranberry Head, clay ironstone nodules become more abundant. In some beds, they make up nearly one-fourth of the whole material.

The strata at the particular horizon now reached are less

uniform in their nature and arrangement than either above or below. Sandstone shades off laterally and vertically into arenaceous and argillaceous shales, and *vice versa.* These horizons then must represent a comparatively prolonged period of rest, during which the debris arranged itself according to coarseness—the coarser sand being deposited nearest shore, while finer and finer material was laid down as depth increased, until at last only the finest clay was deposited. As this went on, the cliffs wore back until they were so far from the earlier shore that the coarsest sand did not reach that water at all. Then only the finer sand, and at length clay, spread over the original coarse sand. This would produce a gradual change from coarse to fine material both seaward and upward, so that now sandstones and shales of all varying textures merge into each other.

Tracing the strata upward through three feet of shale and two feet of lime, another layer of shale follows containing erect Calamites. Nearly all the shale here and for a long distance above, is argillaceous. Changes usually take place suddenly from coarse sandstone to fine clay without the intermediate stages that one might expect. Next above the shale with Calamites, in addition to two thin bands of limestone, are twenty feet of blue gritty sandstone, very much cracked. Since there are no faults or folds here, or any other structure different from that of the preceding beds, it is possible that this sand owing to some peculiar conditions held more water at the time of deposition than the other beds. Later, the drying of the stone caused shrinkage cracks producing the effect now visible.

The next sixty feet of strata present evidence of deposition on a more uneven bottom or in the presence of more erratic currents than any other part of the whole field under discussion. Shales have been cut away and filled with sand, in a remarkable manner.

Proceeding to the next overlying strata, several small seams of coal are found distributed as in tabular section on pages 304 and 309. The sandstone overlying the sixteen-inch seam is a good

building stone, a considerable quantity of which has been quarried for local use. It is rich in fossils of the genera Sigillaria and Lepidodendron. Here, too, I found a cast of the pith of a Calamodendron. It very much resembles the stem of Calamites, but is distinguished by the absence of leaf-scars. The Calamodendron, as now found fossil, appears to be the pith of a stem which had a thick bark and woody coating. This pith doubtless decayed first, and the hollow stem filled with sand or clay. Later the outer part disappeared, leaving a stone cast of the interior. Although this quarry stone contains numerous fossils, very few remain distinct enough to determine their species. Sigillaria trunks are found varying from two to eighteen inches in diameter.

Nearly all the coal seams have clay or shale above them. One, however, the last but two before Lloyd's Cove seam, is overlain by very coarse, gritty micaceous sandstone. Conditions succeeding the formation of this coal must have been somewhat different from those succeeding previous beds. The ordinary fine clay and shale usually overlying the vegetable matter came from the gentle filling up of swamps with fine material during a period of slow gradual subsidence. The coarse sandstone, on the other hand, must have been deposited in moving shallow water near shore. This may very likely have come about by a sudden but comparatively slight subsidence after the prolonged interval of rest during which the coal had accumulated. For, if depression had not been sudden, the water would not have attained sufficient depth to produce waves capable of moving and spreading out the coarse sand without any intervening layer of clay. Nor could the depression have been very great, for then the water would be so deep that coarse sand could not be carried out any distance over the sea-floor. A second possibility is the influx of sand from the action of storms breaking over the low bars into the lagoon behind. In this sandstone, false-bedding is extremely common, but with no particular current direction. Its presence indicates the

probability of vertical oscillation rather than flooding as a source of the sand. Much of the material bears evidence of deposition in shore coves where current eddies would give more irregular bedding than would be possible on a straight shore.

Lloyd's cove making in directly over the measures just described, cuts off observation of the next 200 feet of strata. Crossing the cove, however, the section becomes continuous, remaining so to Cranberry Head—the end of the land surface of this district. Lloyd's Cove seam itself is cut off from view by detritus from the old workings. It is six feet thick, but is cut into three parts by two thin layers of clay. There are two slopes working at present on it, while it is cut at a depth of eighty feet in the "Princess" pit.

The next coal seam is separated from Lloyd's Cove seam by eighteen feet of shale. It contains only five inches of coal, divided into two bands by eight inches of soft shale. From here to Cranberry Head the strata consist largely of shale, with a few bands of sandstone and marl. The total thickness from Lloyd's Cove seam to the Head is about 300 feet. At the headland, two coal beds occur, with fifteen feet of shale and fireclay between them. The upper seam is three and a half feet thick; the lower, one foot. Under the lower seam are one foot of fine clay and two feet of fireclay with Stigmaria rootlets, the whole resting upon gritty shale. The fine shale overlying the upper seam is extremely rich in fossils and leaves of ferns and Cordaites, etc. No other rocks in the whole region except the roof of the Main seam can equal it in its fossils. Some of the plants found here are Sphenophyllum schlotheimii, Pecopteris arborescens, Odontopteris, Sphenopteris gravenhorstii, Pecopteris. Many Cordaites leaves here measure three inches across. About ten feet of strata still overlie the upper seam, before the top of the Head is reached. When the land wears back thirty feet more, however, not a trace of this coal outcrop will remain above water.

Cranberry Head is about forty feet high, standing upon a sandstone base. Since water level on either side finds soft shales, these have worn away, leaving the outstanding firmer sandstone. The front of the head, too, is parallel with the strike, and the dip is directly seaward. These conditions give less chance for wave attack than would otherwise exist. Notwithstanding this, the head must eventually wear away. Brown, writing in 1871, said: "A block, 20 yards square and 15 yards high slipped off from Cranberry Head, forming an island." Although this was not very many years ago, no trace of the "island" now remains. Moreover, as the sea works landward, the cliffs are becoming lower; for here the land surface slopes away from the sea.

Black point.—Around Cranberry Head no new measures are exposed, for the shore either follows the strike or cuts back into beds already seen. At Black point, about a mile from Cranberry Head, are good exposures of coal and strata. The point is sandstone, much broken into cubical blocks, which aids the sea action in rapidly eroding it back. Three coal beds crop here. The lower is one and one-half feet thick, with a foot of fire-clay, resting upon sandstone. Above are six inches of fine clay and marl, then coarser shale ten feet to the middle seam, which is one foot thick. Sixteen feet higher is the third seam, three feet thick, with coarse sandstone above and clay and shale below. All these clays contain Stigmaria rootlets, while the sandstone contains Sigillaria and Calamites. Mr. Charles Robb says these Black Point seams are the same as those cropping at Chapel point. Their enclosing strata go far towards proving his conclusion to be correct. This is especially true of the coarse gritty limestone overlying a coal bed at each point. I have found no other coal seam without clay or shale immediately above. In default of this evidence, however, one would be disposed to call the Black Point beds new ones, owing to the increase in their thickness and in that of the intervening strata

between the two places. But it is not hard to believe that such diversity could occur in that distance, for a difference of some inches in coal and of some feet in strata is often seen in the part exposed in one cliff. Moreover, the Indian Cove seam, for example, where it is now worked near the outcrop, is four feet thick; while in some other places it has been cut through in two feet. The Main seam presents undulative and varying thickness as it is worked at different points. With these facts in view, it is quite probable that the Black Point and Chapel Point seams are the same.

Part II. Summary of History.

The rocks included in the area under discussion are all sedimentary. Nearly all give evidence of deposition in shallow water. This could happen throughont such great depth only in the case of a slowing sinking land. There are a few indications of more rapid or sudden sinking, but rocks formed under suddenly changed conditions are a very small part of the whole deposit.

LIMESTONE SERIES.

Limestones.— The total thickness of strata from Leitch's creek to Cranberry Head is about 6400 feet. The lower beds at Leitch's creek are a laminated calcareous sandstone resting upon limestone. The presence of limestone containing marine fossils is proof of formation under the water of the open sea. After this condition had remained for some time the waters, which must have been shallow, became partly flooded with sand. Its deposition was probably slow, thus allowing it to be so thoroughly impregnated with lime. Since this sand now forms a bed nearly 200 feet thick, gradual depression must have taken place for a long time. At last some change in the supply of detritus brought clay instead of sand, now forming a bed of red shale two feet thick. This is succeeded by limestone which could have come from two sources. Either it could have been carried from some land reef of limestone by water containing

carbon dioxide derived from decaying vegetation and deposited subaerially, by evaporation of water or by loss of carbon dioxide, or it may have been formed under the sea from shells. The presence of land or marine fossils would decide the question one way or the other. I have failed to find them, but Mr. Brown and Mr. Robb report marine fossils. This makes it an ordinary shell deposit. Re-elevation at last brought an end to the formation of limestone, and renewed the supply of sand which in turn was succeeded by clay as before. After a prolonged period of clay deposition the waters at length became clear, and gypsum was deposited.

Gypsum.—Two theories have commonly been advanced as to the origin of gypsum beds:—(1) formation by the action of sulphuric acid on limestone; (2) precipitation from water solutions by other salts, or by partial evaporation. In the case before us either method could have operated. The rocks both above and below are limestones containing iron. The most fundamental compound of iron occurring in nature is ferric sulphide, iron pyrites. By oxidation or through organic influence, this iron is often changed to oxide or carbonate, and finally in a state of solution impregnates other rocks. The sulphur goes to form sulphuric acid. The presence of iron in these rocks points to a probable presence, then, of sulphuric acid. It being supplied, and the limestone already at hand for it to attack, gypsum could result just as we find it.

On the other hand, since it is so regularly bedded in material evidently accumulated under water in a territory of alternate elevation and subsidence, there is no valid objection to the precipitation theory. In some parts of the world, beds are undoubtedly of this origin, where they alternate with rock salt. The absence of an overlying salt bed here can be readily accounted for, from the evidence of seashore and marine deposition where water could not be sufficiently concentrated to precipitate its common salt. It is possible, moreover, that the land

was never sufficiently elevated to form inland seas, where gypsum could be deposited as a result of evaporation. On the whole, the sulphuric acid theory would seem more probable.

A third method of gypsum formation is sometimes attributed (according to W. P. Blake—Trans. Am. Inst. Min. Eng., 1901, p. 715), to collections on dry arid surfaces after the manner of the *caliche*. Since the structure here, however, points to totally different conditions from those belonging to such formations, we may dismiss the subject.

Whether the gypsum was deposited by the concentration or sulphuric acid method, clearly it indicates, like the limestone, a temporary exclusion of the clay supply. Later this supply was renewed, forming the next layer of marl; which, however, was somewhat irregular, as proved by the stringers of bedded gypsum running through it.

The changes outlined above succeeded each other alternately for long periods, since lime, shale, marl, and sandstone alternate until an additional thickness of two hundred feet have accumulated. That it is all calcareous, indicates its deposition under sea water. Ripple marks and rain prints occur at different levels, while material in some cases is uniform for some considerable depth, proving slow subsidence. The occasional sudden change from lime to sand or shale, proves intermittent sudden changes of depositional conditions. This is further evident from ripple marks at a contact of fine shale and coarser sandstone in the railway cutting previously mentioned. The fine shale was deposited in comparatively deep water, or on a mud flat. With a sudden elevation, however, sand was laid down on the shore, for the ripple marks are in the first layer of sand overlying the shale.

At length these oscillatory movements ceased, and for a very long time slow and continual subsidence prevailed, without any intervening elevation. The depression was just rapid enough to allow accumulation to keep pace with the sinking sea bottom, so that shore or shallow water deposits are continuous for great

depths. The advent of this permanent period of sinking marks the beginning of the formation of the Millstone Grit series.

Ironstone.—Between the Limestone and Grit is a bed of impure ironstone. It is possible that this was formed in part later than the adjoining beds as a bedded replacement deposit. The limestone being more soluble than the overling grit, would gradually dissolve away by water following the contact line. The grit is a coarse grained permeable rock, while the limestone is of much finer texture. Water leached from the overlying beds, then, soaked down and overspread the limestone surface, carrying away lime in solution. Iron compounds already existed in the limestone, while additional quantities would be brought in from the grit above. These were deposited in the form of iron oxide in the place previously occupied by lime. This is apparent from the fact that all the calcareous sandstones are red or brown from iron, while the overlying grit is gray as if leached ; and also that the rock containing the iron is silicious to clayey, similar to that containing the lime.

MILLSTONE GRIT.

Cross-bedded sandstones.—With the introduction of the Millstone Grit, variety ceases. In one or two cases an irregularity occurred, sufficient to accumulate beach detritus, which now appears as small beds of conglomerate. In general, however, sand was laid down in shallow water. It graduated from coarse to fine, both laterally and vertically, but the change was seldom abrupt. A few sudden depressions succeeded periods of rest, as is seen in comparatively fine sand resting on conglomerate. False bedding is common, and nearly always in the direction of the dip. Shore phenomena are also evident, from horizontal stems of Calamites, Lepidodendron, and Sigillaria, where they were probably thrown down as driftwood as at the present day. Now and again tangled masses of leaves and twigs occur as if brought there by some current.

Coal seams.—True coal seams are small and few. One often finds coal bands extending only a few feet, and not more than an inch thick. Since they usually contain no underclay, and are of limited lateral extent, they probably represent small masses of leaves and driftwood buried quickly. When true seams do occur, they possibly do not extend far, but have been formed in small restricted shore swamps, much after the manner of the thicker seams of the Coal Measures. The conglomerates contain more iron than the surrounding grit. A conglomerate layer, be it ever so small, usually exudes rusty water. This is due partly to the cementing iron, but is to be explained in part also by the fact that the more porous conglomerate acts as an underground drain by which the grit continues to be further leached of its iron.

The Ingraham coal seam is the only coal that has been worked in the Grit. It must have been formed during a period of temporary elevation of the bottom, or in a cove that had been shut off from the sea. If it had formed during a period of rest, when the land had risen merely by accumulation of detrities, the intervening beach stage with its conglomerate might be expected. This does not exist. The more probable view, therefore, is that since this bed has not been traced far, it is of small extent and formed in a large cove that had been closed up by a bay bar. As the land sank, the bar grew in height until a silting up of 25 feet of shale and underclay in addition to two feet of coal had accumulated. Then the sea again broke over the bar covering the whole area with coarse sand which now almost approaches conglomerate. No part of the bar, if such existed is now visible.

From here to the top of the Grit series no important change in the structure takes place. At Stubbart point, which has been fixed upon as the boundary between the Grit and the Coal Measures, alternations of shale and sandstone again appear. The oscillations which had marked the period of the Limestone

series, but which had almost totally ceased during the formation of the Grit, were resumed. They continue throughout the deposition of the Coal Measures proper; but on the whole, greater elevations were attained here than in the other series, hence greater periods of growth of terrestrial vegetation.

COAL MEASURES.

Alternations of strata.—The alternations of sandstone and shale have already been commented upon. Since the rocks often contain erect trees and undistorted ferns, they must have been deposited in shallower but quieter water than those of the preceding series. The presence of small shells, mostly determined to be fresh water species, and the absence of purely marine limestone fossils, all go to show periods of vegetable growth and sediment deposited in inland swamps and lagoons. The beds of coal and shale often being covered with sandstone, however, may show subsidence or floodings at frequent intervals. Mr. Brown reports finding rill marks, rain marks, and footprints of land animals near Lloyd's cove and in shale overlying coal. These discoveries, with their distribution, prove the proximity of ancient shore lines.

All these beds in turn have had their period of depression beneath the sea, where the pressure of the ocean and the overlying strata has brought about those changes necessary to form solid shale, sandstone and coal. At last, however, they again were forced up by the orogenic activities which gave rise to the Coxheath and Boisdale hills, and became part of the great compound Sydney basin to the east.

DYNAMIC CHANGES.

Uplift against pre-Cambrian.—To the southwest of the Sydney district as a whole are two mountain cores of pre-Cambrian rocks. One of these forms the Boisdale hills, the other the Coxheath hills. Both were uplifted at the close of the Carboniferous. In some portions of the province, as Cum-

berland county, Permian strata have shared in the general deformation; or as in Pictou county, have been slightly deformed, but less than the Coal Measures. Thus there appears to have been a general orogenic disturbance at the close of the deposition of the Coal Measures, with less, and perhaps more local, warping during or after the Permian.

As no Permian is met in the Sydney district, the exact date of uplift cannot be fixed; but it is to be presumed that it was at the close of the Coal Measures, or Carboniferous proper.

The effect was to make a large syncline in the form of a partial basin, with its margins well defined on the northwest, west, southwest and south. This was broken up into subordinate basins largely by the influence of the two cores of old rocks referred to above. The Coxheath core most affected the area under discussion; and its effects may be seen in the northwest dip of the Carboniferous near the head of Sydney harbor, changing gradually to the normal northeast dip as one recedes from the source of influence.

Both the mountain cores gave to the enwrapping sediments the attitude of local anticlines, plunging sharply northeast, and dying out near the present shore of the island. These folds acted merely, however, as local interruptions to the general basin structure.

Absence of post-Carboniferous strata.—Except the Triassic area in the western part of the province, there are no rocks to be found between the Permian and the Pleistocene. In the Sydney district, as elsewhere, it is presumable that the land was above water constantly after the end of the Carboniferous. The evidence here is purely negative—absence of subsequent formations; but throughout the province as a whole, the drainage patterns made by the streams point to a very ancient emergence of the land.

CONTRIBUTION TO THE STUDY OF HYDROXYLAMINE.*—BY G. M. JOHNSTONE MACKAY, B. A., *Dalhousie University, Halifax, Nova Scotia.*

(*Read 9th April, 1906*).

The following investigation, carried out in the laboratories of Dalhousie University, was undertaken at the suggestion of Dr. E. MacKay. The chief object in view was the study of solutions more concentrated than those investigated by W. H. Ross.[1]

Preparation of Hydroxylamine Sulphate.

Considerable difficulty was found in preparing large quantities of hydroxylamine sulphate, and as about 600 grams were required, a portion of the salt used was purchased.

The method adopted was that of Divers and Haga[2] as modified by Maxwell Adams,[3] which method appears to be more satisfactory than the older methods.

On looking over the literature on the subject, several conflicting statements were found. Thus Divers and Haga say that the mixture to be sulphonated should consist of sodium nitrite and sodium carbonate in the proportion of two molecules of the former to one molecule of the latter; Maxwell Adams on the other hand, says one molecule of sodium nitrite to two of sodium carbonate, while Lengfeld[4] gives more than two molecules of sodium nitrite to one of sodium carbonate.

All three proportions were tried, but the two latter were found to give no satisfactory result. Maxwell Adams' directions probably contain a misprint, and should read " one *part* of sodium

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*CONTRIBUTIONS FROM THE SCIENCE LABORATORIES OF DALHOUSIE UNIVERSITY —[CHEMISTRY]

1. Trans. N. S. Inst. Sci., XI, I, 96.
2. Jour. Chem. Soc (Lond.) 69, 1665 (1896).
3. Am. Chem. Jour. 28, 198, (1902).
4. Inorganic Chemical Preparations.

nitrite to two *parts* of sodium carbonate," which would give approximately the same proportions as Divers and Haga, which correspond to the equation

$$2NaNO_2 + Na_2CO_3 + 4SO_2 + H_2O = 2HON(SO_3Na)_2 + CO_2.$$

The method of procedure was as follows :—

500 grams of commercial crystallized sodium carbonate and 237 grams of commercial sodium nitrite were dissolved in 800cc. of warm water, and the solution, contained in a glass cylinder about 10 cm. by 30 cm. in size, placed in a freezing mixture of snow and salt. When the temperature fell to —5° C., sulphur dioxide was passed into the solution from a siphon, the delivery tube acting as a stirrer by being attached to a swivel gear fastened near the circumference of a wooden wheel kept in motion by means of a small air engine. When the flow of sulphur dioxide was so regulated that the temperature did not rise above —3°, sulphonation took from 6 to 8 hours. When the solution thus became neutralized, it was poured into a large flask, a few drops of sulphuric acid added, and the whole heated to between 90 and 95 degrees in a large water bath until the hydrolysis of the sodium oxyamidosulphonate was about complete, the process requiring about 50 hours.

The solution was then almost neutralized with sodium carbonate, cooled to 0° C, evaporated, cooled again to —8°, and a saturated solution of tertiary sodium phosphate added, when the comparatively insoluble hydroxylamine phosphate would separate out.

Contrary to the experience of Divers and Haga, on adding the few drops of sulphuric acid to the sulphonated solution to start hydrolysis, no marked rise of temperature took place.

The following variations in treatment were tried without marked improvement in the yield :

The addition of more water to the solution before starting hydrolysis ;

The addition of a larger quantity of acid to start hydrolysis ;

The addition of sodium carbonate during hydrolysis to neutralize the large excess of acid formed;

Increase of length of time of hydrolysis until disappearance of last trace of the oxyamidosulphonate, 5 or 6 days.

In order to be able to pass sulphur dioxide into the solution more rapidly without raising the temperature above —3°, a copper vessel forming an annular ring was designed so that the freezing mixture could be put around the outside of the solution, and also in the central bottomless cylinder. The solution to be sulphonated, in the annular space, had thus a large surface exposed to the action of the freezing mixture. The delivery tube was rotated in the ring as before.

Little or no hydroxylamine was obtained in this way, however; and a great deal of time was spent in trying to improve other conditions before it was found that the copper had a specific catalytic reducing action on hydroxylamine salts, converting them mainly into ammonium compounds.

Preparation of Free Hydroxylamine.

For the preparation of free hydroxylamine the method of Uhlenhuth[1] was followed. When the chloride was used as the basis of preparation, it was necessary to convert it into the phosphate. 500 grams of tertiary sodium phosphate, prepared from the secondary sodium salt by adding the necessary amount of sodium hydroxide and recrystallizing, were dissolved in 1000cc. of water and added to 273 grams of hydroxylamine chloride dissolved in 600cc. of water. About 200 grams of hydroxylamine phosphate separated from the hot filtered solution on cooling. As there was such a large volume of water present, and as the reagents were pure to start with, it was not necessary to recrystallize.

From 20 to 50 grams of the dried salt, the amount of salt varying with the amount of hydroxylamine required, were put

1. Ann. Chem. (Liebig), 311, 117 (1900).

in a distilling flask fitted with a thermometer with its bulb dipping into the salt. An air condenser about 400mm. long and 10mm. in diameter with about 50mm. of smaller glass tubing joined on to the end, which passed through a rubber cork into a wide mouthed bottle of 250cc. capacity, was attached to the flask. Through another hole in the cork there passed a glass tube to which the exhaust apparatus was connected.

As it was necessary to weigh the pure hydroxylamine, a small tared weighing bottle was placed in the receiver immediately under the condenser so that it would collect most of the hydroxylamine.

The apparatus was exhausted by means of a "Geryk" vacuum pump, a U tube filled with pumice stone soaked in sulphuric acid followed by a calcium chloride tower filled with fused sodium hydroxide and finally by a tower lying on its side spread with phosphorus pentoxide, being placed between the receiver and the pump in order to prevent access of hydroxylamine, sulphuric acid or water vapor to the oil valves. A mercury manometer was connected in parallel with the drying tubes.

After the apparatus was exhausted to 6 or 8mm. pressure, heat was gradually applied to the flask, hydroxylamine passing slowly off until a temperature between 115° and 125° was attained, when, under the same pressure, the greater quantity of the hydroxylamine was expelled. Distillation was stopped when the thermometer rose to 140° as it was desirous to obtain as pure a product as possible, although Uhlenhuth allows the temperature to rise to 170° with the pressure as high as 40mm.

The hydroxylamine, of which about 4 grams would be obtained from 20 grams of phosphate, would condense in the weighing tube, and when jarred or cooled would form perfectly clear crystals, thus showing itself to be practically pure. There was generally, however, a slight odor of ammonia noticeable.

Preparation of Solutions.

The best method for the analysis of hydroxylamine, according to the investigations of Maxwell Adams,[1] is the titration by iodine in the presence of tertiary sodium phosphate. He, however, states that it is not very trustworthy.

My experience has been the same. Working with a standard solution, concordant results could be obtained by always using the same amount of phosphate, but where an unknown amount of hydroxylamine was present in the solution, there being no guide as to the amount of phosphate to be added, very unsatisfactory results were obtained. The end point is also very uncertain, the blue color of the starch fading out almost immediately.

Accordingly in making up my standard solutions, I proceeded directly from the weight of the crystalline hydroxylamine itself, which should give more accurate results than standardization by the iodine titration.

As the solutions when once used in the conductivity cell could not be used again on account of decomposition, each concentration required was made up separately. In the case of 2, 5, and 10 normal solutions, 50cc. and 25cc. graduated flasks were used, and as all of this was needed to rinse the cell and to fill it, a comparatively large amount of hydroxylamine was used.

The flasks used in making up the solutions were 500cc., 400cc., 250cc., 150cc., 100cc., 50cc., and 25cc. 50cc. and 25cc. pipettes, a 10cc. pipette graduated to 1/10cc, and a 50cc. burette were used for diluting. All were carefully calibrated at 18° C.

The various concentrations were made up in the usual way, by dissolving a weighed quantity of hydroxylamine in so much water, removing a portion in a pipette, adding required amount of pure water to bring to the required standard, and then filling up to the mark with the solution which had been removed in the pipette.

1. Loc. cit.

New solutions were made up each day as there was evidence of slight decomposition on standing.

The water used was purified according to Hulett's[1] method. 5cc. of sulphuric acid and 5cc. of a saturated solution of potassium dichromate per liter of water were added to ordinary distilled water in a large flask with a block tin condenser thrust into the neck and held there by means of a cork made of a mixture of asbestos and plaster of Paris. The water thus obtained was redistilled after addition of a small quantity of barium hydroxide. The water finally received had a mean conductivity of 1.6×10^{-6} expressed in Kohlrausch's new unit.[2] The best water obtained had a conductivity of 1.05×10^{-6} and was used for the more dilute solutions. The conductivities obtained were corrected by substracting the conductivity of the water.

Measurement of Conductivity.

Conductivity was determined by Kohlrausch's method with alternating current and telephone. A bridge of Kohlrausch pattern, with four resistances, of 1000, 100, 10 and 1 true ohms was used, and wire of resistance 1.4 ohms wound on a marble drum. Both wire and coils were certified by the maker, Queen & Co., of Philadelphia, to be accurate to within .01% and .02% respectively at 17.5°, and to have a temperature co-efficient of .000267 per ohm per degree centigrade.

The bridge wire was calibrated according to Stroubal and Barus[3] with ten german silver wires of approximately equal length, soldered to stout pieces of copper wire.

The induction coil was of the form recommended by Ostwald, and was kept in an adjoining room so that the noise of the interrupter would not affect the ear.

As pointed out by W. H. Ross[4], solutions of hydroxylamine and its salts are decomposed by platinum electrodes. It was

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1. Ztschr physik. Chem., 21, 297 (1896) and J. Phys. Chem. I., 91 (1896).
2. Kohlrausch u. Holborn ; Leitvermögen der Elektrolyte, 1898.
3. Wied. Ann., 10, 326, (1880).
4. Loc. cit.

found that when a solution of hydroxylamine of fair concentration was put in the ordinary cell of the Arrhenius type with electrodes covered with platinum black, that a vigorous reaction set in with evolution of bubbles of gas and a greal deal of ammonia fumes, due probably to the reducing action of the occluded hydrogen. Even with bright electrodes considerable decomposition occurred, the resistance of a solution in contact with the platinum decreasing from 500 to 200 ohms in 18 hours.

It was thought that it might be possible to use some other metal electroplated on the platinum which would not decompose the solution so much. Accordingly, the following experiment was tried with pieces of the more easily electroplated metals about 18 sq. cm. in area.

Each piece was placed in a beaker and covered with 20cc. of an approximately N/10 solution of hydroxylamine, and allowed to stand at a temperature of 25° for 44 hours. Each beaker was then washed into a 100cc. flask, and duplicates of 25cc. each run out from a burette and titrated with iodine solution in presence of sodium phosphate. Averaging the two results and correcting for end point, it was found that 25cc. of each solution required the following amounts of iodine:

Original solution	11.1cc. N/10 I solution.
Solution with tin plate	11.1
" " platinum	10.5
" " silver	10.5
" " nickel plate	9.9
" " mercury ....about	8.0
" " copper	0.0

It was thus shown that tin decomposed the solution little or none at all, and that copper decomposed it completely, the other metals arranging themselves in the above order. On these grounds an ordinary cell of the Arrhenius type was tin plated from a solution of tin chloride, ammonium oxalate and oxalic acid at a temperature of 65° according to Classen[1], a greyish white coating being obtained.

1. Quantitative Chemical Analysis by Electrolysis.

This cell showed itself to be greatly superior to that constructed of bare platinum, but still slightly decomposed the solution. Thus in a couple of hours an approximately N/5 solution in the platinum and tin cells decreased in resistance as follows :—

	With platinum.	With tin.
Initial resistance	3555 ohms.	3717 ohms.
Final "	2636 "	3201 "
Difference	919 "	516 "

For solutions 1/10 Normal and more dilute, a second cell with pure tin electrodes of larger size and closer together, was fitted up by fusing pieces of stout tin wire to two tin plates about 25 sq. cm. in area, and arranged in the same manner as the Arrhenius cell. The wire was protected by glass tubes passing through holes in the wooden cork and held in place by sealing wax, and as the wire could not be fused into the glass it was left bare for about 25mm. above the electrodes. Of course with this arrangement it was necessary to always introduce the same amount of liquid into the cell so that the same area of the surface of the wires would always come into play. Twenty-five cc. measured from a pipette was the amount used. This cell did not give such a good minimum point with the telephone as the electroplated one.

Before making an observation the cell was first carefully cleaned with pure water, the electrodes suspended at some distance over an electric lamp to dry, the cell rinsed with the solution, the requisite amount put in, and the whole placed in a large thermostat of the form recommended by Ostwald[1], with a stirrer rotated by a small air engine. A thermometer graduated to the 1/50 of a degree and calibrated by the Physikalisch-Technische Reichsanstalt, Berlin, was placed in the bath. By the addition of cold water, or the application of a very small flame under the bath, the temperature of the whole could readily be kept constant to within 1/50 degree of 18°, at which temper-

1. Ztschr. phys. Chem., 2, 565 (1888).

ature the measurements were made. When the electrodes were dry they were connected in the circuit and suspended immediately over the solution in the cell for about ten minutes, when they were dropped carefully into the liquid and a reading made as quickly as possible, the time taken being about half a minute.

After the lapse of about 6 minutes another reading was taken, the change in conductivity being as follows:—

Strength of Solution.	Molecular Conductivity.	Conductivity after 6 minutes.
N/5	·098	·11
N/10	·28	·32
N/20	·40	·43
N/50	·52	·55
N/100	·76	·86
N/200	1·3	1·80
N/500	1·4	1·85

It thus appears that greater relative decomposition takes place in dilute solution. This may be due, however, to the fact that in concentrated solutions minute bubbles of gas adhere to the electrodes keeping the resistance higher until dislodged by shaking.

The conductivity of the pure hydroxylamine, owing to the small amount of material available, had to be determined in a very small cell of about 6cc. capacity. It was made by hammering out into thin plate the ends of two tin wires, and passing them through a piece of paraffin, which served as a stopper to the cell. The wires were filed to thin diameter where the top of the solution would come into contact with them, and a diamond scratch was run around the outside of the cell so that the same amount of solution could always be added. The cell itself was merely a weighing tube, and the hydroxylamine was collected in it directly from the condenser.

For the measurement of the conductivity of water, a cell of the Arrhenius type was used with electrodes platinised according to the formula of Lummer & Kurlbaum.[1]

1. Wied. Ann., 60, 315, (1897)

The cells were standardized by means of N/50 and N/100, solutions of pure recrystallized potassium chloride made with pure water.

The following results were obtained, the specific equivalent conductivities being expressed in reciprocal ohms multiplied by the number of cubic centimeters containing one gram equivalent of hydroxylamine.

The results obtained by W. H. Ross, with bright platinum electrodes, are given in the last column.

The other columns are :

(1) Grams of salt taken per liter.

(2) Volume of solution in liters per gram molecule of hydroxylamine.

(3) Specific equivalent conductivity expressed in Kohlrausch's new unit.

(1) g	(2) v	(3) μ_v	(4) μ_v (Ross).
332·5760	0.0994	·031	...
165·3200	0·2	·018	...
66·1280	0·5	·027	...
33·0640	1·0	·051	...
16·5320	2·0	·093	...
6·6128	5·0	·098	·4
3·3064	10·0	·28	·5
1·6532	20·0	·40	·7
·6612	50·0	·52	·9
·3306	100·0	·76	1·2
·1653	200·0	1·3	1·5
·0661	500·0	1·4	1·9

In consideration of the relatively small decomposition of hydroxylamine solutions in presence of tin as compared with platinum, column 3 may be taken to give more accurate results than any hitherto obtained.

In determining the conductivity of the pure hydroxylamine, the small cell, containing about 5 grams of the substance, was warmed in water at a temperature of slightly above 33°, the melting point of hydroxylamine, until the crystals had liquefied.

The tin electrodes, joined in the circuit, were then inserted and a reading taken as quickly as possible. So slight was the decomposition that the liquid solidified again in a few minutes. The specific conductivity expressed in reciprocal ohms was approximately 83×10^{-6}.

It thus appears that hydroxylamine has a conductivity between that of liquid ammonia at 30° C., 150×10^{-6}, and that of hydrazine hydrate, 34×10^{-6}. On the addition of water, at the concentration of ten gram molecules to the liter, there is a specific conductivity of 310×10^{-6}, which decreases continuously on dilution. In the molecular conductivities there is a minimum point between the concentrations 2 normal and 10 normal. This may indicate that at high concentrations hydrates are formed which are dissociated on further dilution. Unfortunately, owing to lack of time, I was unable to further investigate this anomaly.

Freezing Points of Solutions of Hydroxylamine.

The method used for the determination of the depression of the freezing point was that described by Loomis.[1]

The thermometer used was of the ordinary Beckmann type and had been calibrated by the Physikalisch-Technische Reichsanstalt, Berlin. It was graduated to 1/100 degree and could be read directly to 1/1000 degree by means of a reading microscope with a micrometer eyepiece.

The freezing tube consisted of two parts, an inner tube with re-entrant bottom, 28cm. × 2.8cm., and an outer tube providing an air jacket of about 1.5mm. thickness. The inner tube was supported in the outer by means of rubber bands. The thermometer was held in position in the inner tube by an ebonite cover and a rubber cork a few centimeters below, through both of which were glass tubes to allow the stirring rod of thin glass

1. Phys. Review, 1, 199, (1893); and 9, 257, (1899).

rod bent in a ring at the bottom, to pass through. A platinum stirring rod could not be used owing to its decomposing power on the solution.

In the determination of the freezing point of the solution, these tubes were surrounded to their neck in a glass vessel 35cm. high and 11cm. in diameter, called the protection bath. This stood in a large earthenware jar containing snow and water. The bath was kept at 0·3 degrees below the freezing point of the solution under investigation. The vessel was provided with a stirrer made of stout copper wire, and was covered with a thick wooden cover.

Two more glass vessels of about the same size as the protection bath were also used. One contained a mixture of snow and salt at a temperature of about—10°, and was used to supercool the solution whose freezing point was to be determined. The other contained water at a temperature of $+5°$ and was used to melt the ice formed in the tube.

The hammer of an electric bell supported over the protection bath and driven by an Edison-Lalande battery was used to tap the top of the thermometer before the reading.

In determining the freezing point, the inner tube was filled up to a mark on the glass with about 50cc. of the solution at about 0°, and placed in the freezing bath where it was kept with continuous stirring until ice formed, when it was removed to the melting bath and stirred until nearly all the ice had disappeared. It was then again removed to the freezing bath and stirred until the mercury after falling commenced to rise when it it was quickly transferred to the protection bath, the hammer set in motion, and after two minutes of continuous stirring and tapping, during which time the mercury assumed its highest position, a reading of the thermometer was taken. The whole operation was then repeated 6 times and the mean of the different readings taken.

By judiciously controlling the degree of overwarming, the overcooling could be kept within 1/10 of a degree. As the overcooling seldom exceeded this, it was not considered necessary to make any correction for change in concentration, as the degree of accuracy otherwise attained would not justify it.

The solutions used were made up according to volume at 18° C., and the molecular depresssion calculated according to Arrhenius. The water used was the same as that used for the conductivity measurements, and the freezing point was determined each day in order to eliminate errors due to variation in the barometer.

The following results were obtained :—

Grams of NH_2OH used per liter of solution.	Number of liters per gram molecule.	Depression of freezing point	Molecular depression.
33·0640	1	1·7746	1·77
16·5320	2	·8900	1·78
6·6128	5	·3607	1·80
3·3064	10	·1808	1·81
1·6532	20	·0950	1·90
6612	50	·0391	1·96
·3306	100	·0204	2·04
·0661	500	·0045	2·25

These results are in general agreement with the conductivity measurements, at corresponding dilution, in showing the slight dissociation of hydroxylamine solutions.

For the sake of comparison, it may be of interest to give the values of the molecular d pression by ammonia in aqueous solution as found by Jones[1], and also the specific equivalent conductivities for ammonia, and potassium hydroxide, taken from Whetham's[2] tables.

1. Zeitschr. phys. Chem., 12, 623, (1893).
2. Theory of Solution, 1902.

Molecular depression of ammonium hydroxide in solution :—

Grams per 1000cc.	Normal.	Lowering.	Molecular lowering.
.081	.002310	.0053	2.2943
.16078	.004586	.0099	2.1587
.23937	.006827	.0142	2.0800
.31678	.009035	.0185	2.0476
.40500	.01155	.0229	1.9827
.90450	.02580	.0510	1.9767
1.35405	.03862	.0759	1.9653
1.75865	.05016	.0984	1.9617

Specific equivalent conductivity of solutions of ammonia, potassium hydroxide and hydroxylamine, expressed in Kohlrausch's units :

Number of gram equivalents per 1000cc.	10	5	3	2	1	0.5
Specific equiv. cond of NH_2OH..	.03	.02	....	.03	.05	.09
" " NH_3	.05	.25	.35	.... .	.89	1.27
" " KOH.....	45.0	105 2	139.7	......	182.6	195.7

Number of gram equivalents per 1000cc.	0.2	0.1	.05	.03	.02	.01	.006	.005	.002
Specific equiv. cond of NH_2OH..	0.1	0.3	0.4	....	0.5	0.8	......	1.3	1.4
" " NH_3	....	3.3	4 6	5.3	....	9.8	12 3	...	20.2
" " KOH.....	....	211.1	217.4	220.9	....	225.8	227.6	.....	227.5

The results obtained in the present paper may be summarized as follows :

(1). By the use of tin electrodes, the conductivity of solutions of hydroxylamine has been more accurately determined than hitherto.

(2). The molecular conductivities show a minimum point between the concentrations 2 and 10 normal.

(3). The specific conductivity of pure hydroxylamine has been determined.

THE attention of members of the Institute is directed to the following recommendations of the British Association Committee on Zoological Bibliography and Publications :—

"That authors' separate copies should not be distributed privately before the paper has been published in the regular manner.

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"That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

"That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules of quotation, such as that recently adopted by the French Zoological Society."

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THE

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PRE-CAMBRIAN VOLCANIC BOMBS FROM NEAR LAKE AINSLIE, INVERNESS CO., N. S.—BY HENRY S. POOLE, D. SC., ASSOC. R. S. M., F. G. S., F. R. S. C.

(Read 17th October, 1904.)

Among the rocks of Cape Breton, N. S., classed in the Report of the Geological Survey of Canada of 1882-4 as pre-Cambrian, in a deposit on the east side of Lake Ainslie, are some globular balls associated with modified forms presenting marked features. They differ in so many respects from concretions ordinarily seen taking spherical shape in sandstones, plaster and shales, that these balls could not be grouped with them and thus dismissed. It may first be noted they are found with pyroclastic rocks, and next that such concretionary structure as they do present is in most cases merely superficial; they are associated in a bed which has cavities coated with matter that has flowed while in the condition of thick mud or paste and retained the forms then taken as ridges and layers of varied consistency. The balls have an indurated appearance with a smooth surface, and vary in size from that of a pin's head to a cricket ball. Rarely over three inches in diameter, the largest seen was a flattened oval of 7 in. by 5 in. by 3 in. that apparently had lost, through impact or pressure on contact with

others, an original shape more nearly spherical. The crushing it was subjected to, would appear to have taken place when the interior was still in a semi-plastic state and the crust alone was broken into irregularly shaped plates, the edges of which were more or less displaced. The distortion of form which the balls suffered on impact varied in degree with their size and plasticity. Some retained their form unaltered when they dropped to earth, others appear to have had an exterior sufficiently viscid at the moment of contact to coalesce, while yet others suffered deformation without cohesion, or had their crust fractured, while the displaced pieces were held together by the pasty condition of the interior. While I have said the external surface of the balls is smooth, this statement requires qualification, as parts have a rough or broken appearance where they have been in contact with others. A few show where a spherulitic structure with fibrous radiations has been developed, a form recognized as incipient of crystallization in igneous rocks of the more acid constituents. There was also to be seen on one or two specimens a faint trace of venation somewhat similar in character, and this feature has also been detected on the ridges of flow structure with the associated ash bed. Contact probably gave to the surface of the softer balls a cup-shaped depression, or flattened or simply depressed it, the ultimate form retained by the balls doubtless being determined by the relative hardness of the impinging bodies. Some of the forms found were oblong with rounded ends and somewhat constricted in the middle ; they had a dumbell-like appearance fitting into the inequalities of one another with, in many cases, such slight adhesion that at a light tap of the hammer a group of them would fall apart.

Of the largest a fragment has been put in the Provincial Museum It presents a curiously pitted appearance all over its surface, giving to the plates, into which the crust is cracked, a likeness to the scutes of ganoid fishes ; and taken alone it might be supposed to be part of a fossil.

The pitting is fairly uniform and about of the size and depth given to the depressions on the top of ladies' sewing thimbles. An appearance somewhat similar may be produced by stirring on a glass plate or other non-absorbent surface a thick mud of proper consistency, and allowing it to dry. When mud is rightly prepared and globules of air are incorporated in the mass, there is left on evaporation a coating having a pitted surface like that on this stone. To account then for this pitting phenomenon we may assume that the final concentric coating possessed such a consistency and the usual cementing qualities. I may add that Mr. M. V. Grandin, of Cheticamp, informs me he has seen the same external structure on fragments of lava on the slopes of Vesuvius.

On fracture these balls show an interior of irregular composition sometimes with cavities, parts being granular and easily pulverized and parts being like that of the outside coating, of a fine homogeneous material. The cavities were not found to contain crystals, but one was lightly bridged over by a crust not a 32nd of an inch thick. The concretionary exterior may be somewhat shelly, and shows that it has gathered additions splashed on in drops or patches. These are easily distinguishable by the slight irregularity of form thereby produced, which is often enhanced by a variation in col ring. That the accretions have been of varied degree of fluidity, is made evident by the extent to which they have spread out over the spherical surface, and their appearance would remind one who has visited a pottery establishment, of the action of 'slip' on the clay forms in the hands of the potter.

Besides the deformation due to impact or pressure, it will be seen they have suffered fracture under two distinct conditions, one in common with rocks in general from shrinkage in some ordinary form, and the other exceptional and attributable to sudden violence while in a non-homogeneous state such as is possessed by many articles of domestic confectionary like

chocolate drops and meringues. Pieces of the fractured crust of some of the smaller balls appear to have fallen out and been lost at the time.

I have yet to speak of another feature, and that not of any lesser interest than the foregoing. Parallel to the major diameter of several of the balls, there is a more or less complete striation or grooving around the circumference. The grooves may be single or double, and have a width of as much as an eighth of an inch, while the striæ are more numerous and in a belt of fourteen or more on a scale of even less than thirty to the inch. In the specimen on the table this equatorial linear engraving can best be seen when light is made to fall parallel to the axis of rotation. It is further to be seen passing under the remains of an adhesion giving priority to its formation; but how this engraving was produced, or how the tool which made the lines was held, I am at a loss to suggest.

We may now consider how came these balls of matter, doubtless volcanic ashes, to acquire their present form, and under what conditions would it seem most probable they were produced? Whatever may be the ultimate concensus of opinion, it seems to me their formation can best be conceived by comparison with that of a modern volcanic bomb, and is due to swirling gases of an explosion giving a gyratory motion to the ejected particles of attrition and their aggregations.

Messrs. Chamberlain and Salisbury, in their recent work on geology,* write :—"The larger masses of lava ejected into the air are often caused to rotate by the unequal force of the projection, or by the unequal friction of the air, and to assume spheroidal forms. . . . These rounded projectiles are known as volcanic bombs." Of the ejected dust from Vesuvius they further say— "A finer variety [than lapilli] of the nature of sand, much used in making Portland cement, is locally known as puzzolana." This latter quotation is made as bearing on the rapid cementa-

*T. C. Chamberlain and R. D. Salisbury, *Geology*, 1904, vol. 1, p. 386.

tion which apparently took place in the crust of our Ainslie bombs under consideration. Another extract from the writings of an authority on volcanic rocks I make as apposite to the question at issue. Professor I. C. Russell, writing on the eruptions on Martinique in 1902, says—" In addition to the angular fragments of fresh lava, minor quantities of more or less spherical masses of similar material, which were projected into the air while yet moderately plastic, have also been observed. While the term volcanic bomb has been applied to much of the ejected material, it is evident that only the somewhat spherical masses referred to deserve to be so called, and even in such instances there is doubt as to the propriety of using the term. Typical volcanic bombs have a round or oval form with extended and spirally twisted projections at the ends of the longer axis, the spherical or more commonly oval form and the spirally twisted extremities being due to the rotation of the mass during its serial flight and while yet plastic. . . The nearest approach to a characteristic bomb are certain rudely spherical masses of lava with cracked surfaces and without protections to which have been given the name of Breadcrust volcanic bombs. Evidently these poorly shaped bombs are composed of fresh lava which was sufficiently hot to make it somewhat plastic at the time it was blown into the air, but was too rigid to acquire the typical shape frequently to be seen about certain basaltic craters. The absence of characteristic bombs on Martinique and St. Vincent is in keeping with the composition of the lava thrown out. The fresh lava is an andesite having in a general way the composition of refractory brick, and unless very highly heated would not be plastic. . . Not only are true volcanic bombs absent, but dots and splashes of plastic or fluid rocks such as are common about many volcanoes that have erupted easily fusible material are also lacking."

In the case of the Ainslie bombs, the composition is more acidic than andesite, and there is an entire absence of fusion in the mass, without any trace being observed of the spiral pro-

jections belonging to characteristic bombs. We have therefore to assume some marked change in the conditions to meet their peculiarities, for the special interest which these balls of undoubtedly igneous origin possess, lies not merely in their being volcanic bombs of very ancient geological horizon but in the presumption that they indicate phenomena of unusual type and a rapid cementation of volcanic ashes of a composition differing from those of ordinary modern volcanoes which, generally highly basic, make a mud which of itself does not possess the property of speedily setting as a cement.

The value of intimate grinding to an extreme fineness is well known in the manufacture of commerical cement, but conditions could not be reproduced which are effected during a volcanic explosion when the separation of impalpable dust is under the influence of the chemical agency of superheated steam and other gases, and which for the moment, it is here assumed, existed when these bombs were taking their natal flight. The late exhibition of vulcanism at Martinique and St. Vincent makes the contemplation of a rapid setting cem nt within reason, but requires that the composition of the powder be otherwise than that met with in the ejecta of the Lesser Antilles.

A complete comparison is not at present possible, as no ultimate analysis of the Lake Ainslie ash-bed has been made. That it materially differs from that of the dust from the Windward Islands is evident. Analysis showed the latter to be very basic, with an average of 55% of silica at St. Vincent, and 62% of silica at Martinique; while from the accompanying letter from Dr. Hoffmann of the Geological Survey it is clear the silica contents of the Lake Ainslie rock is very much higher.

OTTAWA, AUGUST 8TH, 1904.

My dear Mr. Poole.

I duly received your letter of the 30th ult., as likewise the specimens therein referred to. With regard to the "concretions of felsite." In so far as composition is concerned, they co sist essentially of silica, with a little alumina, etc., etc. The amount of alumina, in the specimen examined, was comparatively small

and would represent but a small proportion of felspar. Thin splinters of the material are with great difficulty fusible before the blowpipe, becoming in fact only just, and no more, rounded on the thinnest edges. This also would tend to show that the amount of felspar present is but small. There is not, so far as I am aware, any fixed ratio between the quartz and felspar in what are commonly designated felsites. Hence the material in question might by many, if not most, be referred to as felsite —and possibly permissively so. They exhibit an unmistakable concentric structure. I am disposed to refer to them as "slightly felspathic quartzose concretions." When next writing would you kindly mention locality of occurrence, and I will then place the same in our museum collection—duly crediting you with the presentation.

I remain,
Yours faithfully,
G. CHAS. HOFFMANN.

The locality where these bombs were found is on the Gairlock mountain road, half a mile from the east shore of Lake Ainslie, on the slope of the hillside within the loop which the road makes opposite the entrance to the ravine and within a stone's throw of the barite mine on the lands of Johnstone. The barite veins occur in a reddish volcanic ash or quartz-felsite and the bed of bombs appears to be at or about the contact of the ash bed with a band of basic volcanic rocks. The limits of the trap rocks are easily distinguished, as its beds are all dark in color while that of the quartz-felsite varies through light shades of yellow and pink to those of a reddish cast, weathering even to whiteness with minute crystals of sanidine (?) sparkling on the faces of fracture.

The deposit was very superficially exposed and where it had been long subject to surface influences. It seemingly was on edge, and apparently considerable excavation would be required to lay bare the bed where it had not been disturbed in order to establish the relation of the basic lava flows to the highly silicious tuff to which evidently belongs the special portion of the deposit containing the bombs, and a further

investigation of the relation of these very distinctive varieties of igneous rocks would be desirable.

The views respecting the formation of these bombs which I would offer for consideration are these, that during the propulsion upwards of the erupted dust and steam, there was a rapid growth of these spherical forms, augmented during flight, after partial cooling had taken place, by additions received from instrusions of fresher and hotter blasts meeting the descending bombs; that the agglomerates resulted from the clash of matter still in the formative stage and the process of cementation was very rapid and took place during the time of flight, the drying of the crust being completed in many cases even before the bombs fell back to earth.

Notes on the Ore Deposits of South Cheticamp, Cape Breton Island, N. S.—By M. V. Grandin, Cheticamp.

(*Read 17th April, 1905.*)

One of the most interesting and instructive mining districts of Nova Scotia, especially for the study of certain peculiar structural features of ore deposits, is that of Cheticamp.

PHYSICAL GEOGRAPHY.

The district lies in Inverness county, on the north-west side of the Island of Cape Breton, about 110 miles north-east of Pictou, from which place it may be reached by steamer during the season of open navigation. During the winter, however, the most direct route is by mail-coach from Inverness—the terminus of the Inverness railway—a distance of about forty miles.

It comprises a tract of country about 13 miles in breadth, extending along the Gulf of St. Lawrence in a north-easterly direction from Factory river to George's brook—a distance of 16 miles; its area being about 200 square miles. The most trenchant and conspicuous natural division of the district is into a narrow seaboard plain and a plateau lying to the east and north-east of the plain. But for the purpose of this description the great gorge of the Cheticamp river, which traverses the district from south-east to north-west is taken as the dividing line between North and South Cheticamp. The principal metalliferous deposits are located in the southern division which embraces almost the whole of the plain and more than half the plateau area included within the district. The barite and other deposits of the northern division have been made the subject of investigation by Dr. H. S. Poole, so they will not be described in this paper.*

* See bulletin to be shortly issued by Geological Survey of Canada.

The plain, which embraces the island of Cheticamp, covers but one-tenth of the area of the district. It stretches along the shore between Factory and Cheticamp rivers—a distance of nine miles, and rarely exceeds two miles in breadth. Its surface is traversed in a north-east and south-west direction by long low undulations, which towards the east and north, along the foot of the grand escarpment of the plateau, break up into hummocks and high ridges.

The harbor, which was originally a narrow strait running parallel to the undulations and severing the island from the mainland, but now silted up at the southern end, is about 3½ miles long and a little over a quarter of a mile wide. It is the only well sheltered harbor on the western coast of Cape Breton and requires but little dredging to keep it open. Ice, however, commences to form during the latter part of December and lasts from then until the latter part of April or early part of May, during which time navigation is entirely suspended. From this cause and the absence of railway communication with other parts of the province, the development of the resources of the district has been much retarded.

The plateau, with its almost severed stumps, comprises the remaining nine-tenths of the district. It is a portion of that great dismembered branch of the grand Appalachian group which embraces the larger part of northern Cape Breton. The front line of the tableland runs approximately parallel to the coast-line, except at a little south of the middle where it is broken by an embayment into which extends a tongue of the plain traversed by the Cheticamp river. North of Jerome brook, the plateau and its stumps rise precipitously out of the sea or from narrow level terraces; south of this brook it rises almost equally as abruptly from the plain. The average height of the plateau is about 1100 feet. Its surface, especially along the edge, is frequently deeply trenched by huge gorges and ravines cut by innumerable brooks and streams in their descent to the sea.

The drainage system of the district corresponds in its principal lines with the general slopes of the surface, which are from south-east to north-west. The main artery is the Cheticamp river, which enters it from the east a few miles north of the middle, runs south-westerly towards the centre for about 2½ miles and thence north-westerly for nine miles through a deep, dangerous and almost impassable canyon to its beautiful salmon pools where the gorge widens. From thence it continues approximately the same course for three miles, when after cutting through Black mountains it debouches on the Cheticamp plain and flows northerly to the Gulf of St. Lawrence. The river is, like mountain streams, rapid and shallow, and is nowhere navigable, except for small boats near its mouth, It receives many large brooks from the north and south. One of its most important southern tributaries is the L'Abîme brook, in the drainage basin of which the principal metalliferous deposits of the district are situated. This brook has its origin in some ponds and swamps about five miles in a south-easterly direction from its junction with the Cheticamp river. For 2½ miles from its source it flows quietly across the plateau, after which it descends wildly through a deep ravine for the remainder of its course. One of the principal feeders of the L'Abîme is the McLeod, which joins it from the west, a mile above its mouth. About three-quarters of a mile above its junction with the L'Abîme and shortly after commencing to deeply trench the plateau, the McLeod brook receives the Grandin brook from the south and then descends in a north-easterly direction in a series of cascades through a deep wide gorge. The Grandin brook is a very small stream and flows northerly through a narrow ravine.

The plain is mostly cleared and under-cultivation. The slopes of the gorges and ravines of the plateau are clothed with many kinds of woods, conspicuous among which are the birch, maple, beech, spruce and fir ; but on the higher and more level surfaces of the tableland the prevailing vegetation is stunted

spruce and fruit-bearing bushes interspersed with the rank herbage which flourishes in the great wastes of marshland.

The district possesses a most remarkable diversity of scenery. Its most striking feature is the grand escarpment of the plateau, rising from sea and plain in lofty mural and castellated cliffs, majestic talus-slopes and precipitous and craggy acclivities. Its coast-line scalloped into long and grateful curves, presents, especially the northern part, a succession of bold headlands and picturesque bays and coves. Along its shores may be seen an endless array of strange, fantastic and beautiful forms carved by the sea out of its many-hued rocks. From the higher summits of the region, glorious panoramic views are unfolded of plain and plateau. Looking towards the former, spread out like a map at our feet, we see sparkling streams winding across it to the sea, and over its surface dark copses of fir alternating with bright green patches of cleared land. Turning towards the plateau, stretching as far as the eye can reach we see a great wilderness of pristine forest, moreland and rock. Here and there its surface is seen cut into labyrinths of gorges and chasms with foaming torrents, tumbling cascades and deep secluded salmon and trout pools.

GENERAL GEOLOGY.

The relationship of the rocks to the forms of the surface can only be briefly referred to in this paper.

The trend of the coast-line and that of the undulations of the plain, the course of the escarpment, the position, size and shape of the harbor and the island, have all been largely determined by the strike and the nature of the underlying rocks. The law of the survival of the strongest and fittest holds good in physiography as in biology. The softer rocks have suffered the most from erosive agents and left the harder as the salient features of the district. The granitic rocks which consitute the front of the plateau have acted as protecting barriers to the softer schists which lie beyond them, and have determined the trend and retarded the recession of the escarpment.

The courses of the principal streams appear to have been mainly determined by the original slopes of the surface; but those of the smaller brooks and torrents have been influenced chiefly by fault lines, the disposition and lie of the schists and the relative resistant power of the rocks.

Two great systems of rocks are represented in the district—the pre-Cambrian and the Carboniferous. The classification of the former into series has not yet, on account of the complexity of the problem, been attempted. The Carboniferous are divided into two series:—the Lower and the Middle. Broadly viewed, it may be said that the pre-Cambrian rocks occupy the plateau, and the Lower Carboniferous the fringe of hummocks and ridges along the foot of the escarpment, and the plain. The rocks of the Cheticamp Island are regarded by Mr. Hugh Fletcher as Middle Carboniferous.

The pre-Cambrian formation consists mainly of granites, syenites, felsites, gneisses and schists. Granitic rocks, cut by dikes of trap, predominate along the edge of the plateau. These give place towards the interior of the district to patches and belts of schistose rocks alternating with or surrounded by massive igneous rocks. The whole formation has been much plicated, sliced horizontally and vertically by shear and thrust planes, and in consequence of these mechanical movements and the chemical action thereby set up, most of its rocks have been converted into varieties of gneisses, schists and other foliated rocks.

The massive igneous rocks are frequently metalliferous, but it is the schists that have so far proved the principal ore-bearing rocks of the district and in them the important deposits have been located.

A powerful fault, traversing the district from north-east to south-west and following the course of the escarpment, separates the pre-Cambrian from the Carboniferous. The latter is represented by conglomerates, sandstones, shales, gypsum and lime-

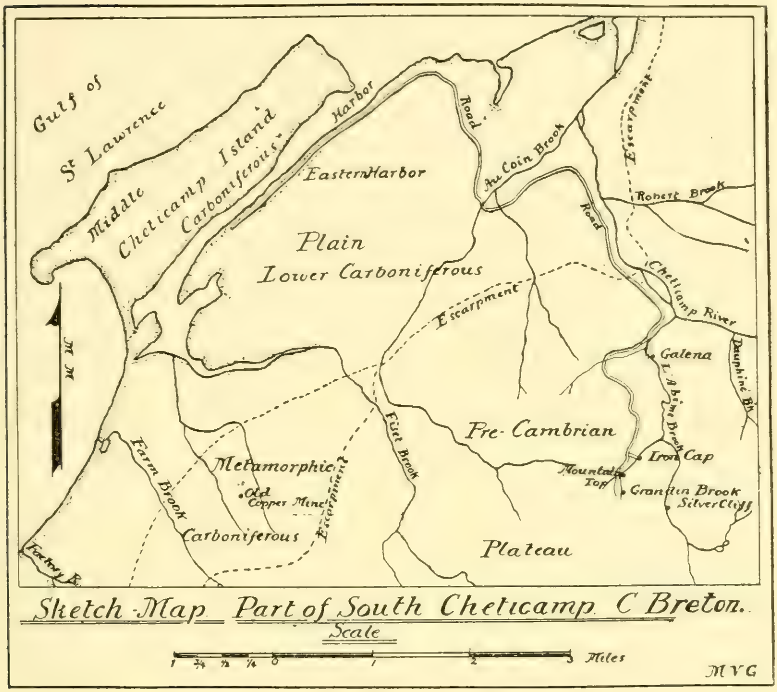
stones. Conglomerates and sandstones, more or less metamorphosed, form the high ridges which run parallel to the edge of the plateau. Along this boundary fault, these rocks are highly tilted, generally dipping seaward, but sometimes bent back upon themselves. They are also frequently faulted, crushed and cut by trap dikes. In places they give promise of workable deposits of copper, but elsewhere in the district the Carboniferous rocks are apparently barren. These metamorphosed sandstones are succeeded by thick beds of gypsum and limestone which form the hummocky land. The geological features of the plain and island are comparatively simple. The rocks of these tracts are principally sandstones and shales. Those flooring the plain, dip seaward, while those of the island have a general dip towards the mainland.

THE L'ABIME ORE-BEARING SCHISTS.

The principal metalliferous deposits of the district are located in a belt of schists occupying the drainage basin of the L'Abîme brook. They are easily accessible from Eastern harbor by road. (See map.)

The belt consists mainly of serecite, chlorite and hornblende schists, which appear to have been produced by the metamorphism of an original stratified series—their plains of foliation being guided by the stratification of the original materials. A definite order of succession can be made out among them and their groups of serecite and other schists traced continuously over long distances.

The structure of this area is an extremely complicated one. In the uplifting of granitic masses to the east and west of it, the whole tract was subjected to enormous mechanical movements which not only threw its rocks into wave-like folds but dislocated them by reverse faults and cut them into slices by shear and thrust planes. The longitudinal axis of the folds strike approximately N. N. E. aud S. S. W. In the central part of the area they pitch S. S. W. or S., whereas in the



Sketch-Map Part of South Cheticamp C Breton.
Scale

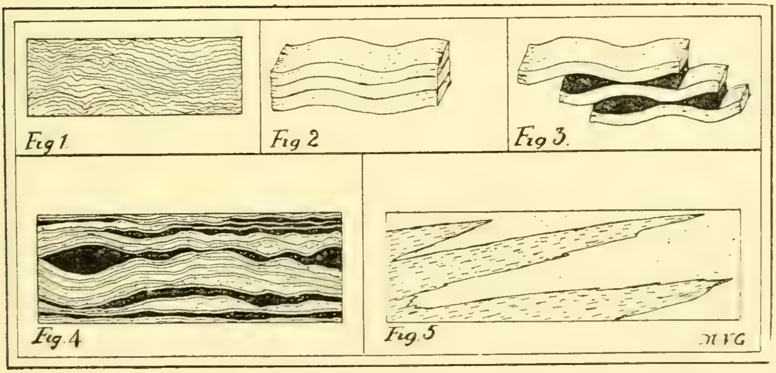


Fig 1. Fig 2. Fig 3. Fig. 4. Fig. 5.

northern part they are, when observed, inclined to the N. N. E. or N. This pitching of the axes may have been caused either by their being broken across the strike or by transverse east and west upheavals. The lines of movement run in certain definite directions and principally along lines of shearing and thrust planes. They may be grouped into two systems at least:—(1) Those running N. N. E. and S. S. W., and (2) those trending E. S. E. and W. N. W. or E. and W. and approximately at right angles to the first system. In a general way it may be said that the vertical lines of shearing or cleavage-foliation run parallel to the strike and the thrust planes coincide with the stratification-foliation planes of the schists.

To still more complicate the structure of this complicated belt of country, cross undulations and contortions have been developed on the flanks of the main folds which cause great irregularities in the lines of outcrop.

These movements appear to have developed considerable volcanic activity and the schists were cut by dikes of felsite and diorite which in places seem to have some genetic association with the ore deposits.

THE PRINCIPAL ORE DEPOSITS.

Grandin brook copper deposit.—The ore deposit in which development work is in the most advanced stage, is that of Grandin brook, which is situated on the edge of the plateau near the junction of the McLeod and Grandin brooks. The work consists of a slope at its most southerly outcrop, several lateral openings made at intervals for about 900 feet along the right bank of the Grandin brook ravine and the stripping of the vegetation and débris from the precipitous cliffs in which it outcrops in the McLeod brook gorge. It consists of several beds, aggregating probably not less than 250 feet in thickness, of serecite and chloritic schists impregerated with copper pyrites. These beds are locally known as the "copper schists," and rest on the schists which outcrop in the McLeod brook and which

are of considerable but undetermined thickness. The McLeod rocks possess somewhat similar lithological characteristics to those of Grandin brook and like the latter carry metallic sulphides disseminated through most of their beds. There is, however, as a rule, a marked difference in the nature of the sulphides carried by the two groups. Arsenopyrite, which is the dominant ore of the McLeod rocks, is conspicuous by its absence in the "copper schists." The nature of the rocks overlying the deposit has not yet been determined, as the hanging wall has not been reached; but the data so far collected indicates they possess characteristics similar to the underlying beds. The "copper schists" at their outcrop in the Grandin brook strike N. N. E. and S. S. W., with an average dip of 45° to the E. S. E.; but owing to the axis of the fold pitching S. S. W. at about an angle of 10°, the deposit is tilted up towards the north at its outcrop in the McLeod cliffs and then it has been ground down by detritive agencies to a thickness of about 40 or 50 feet. The characteristic cross-folds and contortions of the L'Aîbme schists are well illustrated at the deposit. Fig. 1 gives some idea of the tumultuous nature of the smaller contortions. The same pressure which produced the cross undulations, not only caused horizontal displacement of the beds, but caused the layers to slide over each other, by which movements cavities were developed. Many of these cavities have no doubt been modified in shape by the corrosive action of circulating fluids, but their original shape has generally been fairly well preserved. Figs. 2 and 3 represent the manner in which the lens-shapes were produced. Fig. 2 represents the corrugated beds before, and Fig. 3 after the sliding movements had taken place. This structure is characteristic of all the L'Abîme deposits; but is not so well illustrated at Grandin brook as at Iron Cap and Galena, as owing to the minuteness and the great abundance of the contortions of the "copper schists" the lenses are usually extremely small. Fig. 4 shows another structure, common to all the deposits, which has been

developed by forces pressing on the end lines of stratification. Both these forms of cavities were no doubt produced in most cases with but comparatively little horizontal displacement of the beds and layers. Below the zone of oxidation they are generally found filled with copper- and iron-pyrites or quartz, but at the outcrops where their metallic contents have been leached out they can usually be more easily studied. The copper-bearing solutions appear to have gained access to the cavities by travelling up and along the planes of jointing, shearing and foliation, as there divisional planes are frequently covered with thin sheets or films of ore. These thin sheets and minute lenses constitute the bulk of the ore at Grandin brook.

The surface characteristics and products of copper deposits may be seen at Grandin brook. At and near the surface, to a depth of from 5 to 15 feet, the metallic contents of the schists are often completely leached out leaving the rock in a cellular and porous condition. The schists at the surface are rarely stained, being, although normally of a greyish or greenish color, bleached nearly white. A few inches below the surface, however, they are generally discolored by limonite. This leached zone gradually passes into one in which green carbonates predominate, and this in turn into one containing a mixture of partly decomposed copper pyrites and carbonates which rapidly gives place to an unoxidized copper pyrite zone.

The outcrops of all the L'Abîme deposits are somewhat difficult to follow, as although admirable sections are occasionally laid bare in brooks and cliffs, they are usually covered with superficial deposits, forests, dense thickets, swamps and bays. The tendency of the ores to decompose and become leached out where the rocks are exposed to surface agencies, and the general resemblance of the rocks to each other, also add considerably to the difficulty. The course of the outcrop of the "copper schists," however, has been traced by means of "float" and a few exposed sections for a distance of nearly a mile.

The Grandin brook deposit is owned and is being developed by the Cheticamp Copper Company, Limited, Halifax.

As all the deposits of the L'Abîme area resemble one another very closely in the mode of occurrence of their ores only the peculiarities or exceptionally well developed structural features of the following deposits, will be described.

Mountain Top.—The Mountain Top deposit outcrops in the deep gorge of the McLeod brook near the mouth of the Grandin and immediately beneath the "copper schists." It consists of four distinct beds of schist which in descending order are as follows :—

1.	Chlorite.	Not explored.	Thickness not determined.	
2.	Serecite,	$4\frac{1}{2}$	feet	thick.
3.	Chlorite,	25	"	"
4.	Serecite, about	50	"	"

These rocks outcrop on or in close proximity to an anticlinal axis which pitches S. S. W. at about 10°. Along the crest and flanks of the fold, undulations have been developed with their axes parallel to the axis of the main fold. No. 1 is harder than normal varieties of chlorite schist and carries auriferous arsenopyrite associated with chalcopyrite in lenses and veins of the compression type (Fig. 4.) The lower chlorite No. 3 is very much softer than No. 1, and is remarkable for its crumpled and contorted folia. It carries arsenopyrite and pyrrhotite in lenses and veins similar to those of No. 1. In No. 2, the ore is also distributed in much the same way, and consists principally of auriferous arsenopyrite. No. 4 is a very hard serecite approaching quartzite in appearance and hardness. The planes of shearing which are here well developed are grooved and fluted in the most beautiful manner so that portions of the rock have some resemblance to prostrate Corinthian columns. Veins of the compression type predominate in this bed. The ore is more concentrated for about 10 feet below its junction with No. 3, and from this zone samples of arsenopyrite

have been taken carrying as high as $90 in gold per ton. But although these phenomenal values have been shown, the deposit is essentially a big low-grade proposition, as are the other deposits of the L'Abîme.

The outcrop has been traced over a large area, but work has as yet been confined to its outcrop in the McLeod gorge. This property is owned by the Richfield Mining Company, Limited, Halifax.

Iron Cap.—Next to the Grandin brook deposit, Iron Cap is in the most advanced stage of development. It outcrops 500 yards E. N. E. of Mountain Top in precipitous cliffs along the right bank of the McLeod brook which here flows easterly 600 feet below the general level of the plateau. The deposit consists of a bed of chlorite schist of undetermined thickness carrying auriferous arsenopyrite and pyrrhotite. The bed has been stripped along the brook for a distance of about 200 feet exposing a section of about 25 feet in thickness. The schists are here seen to be bent into an anticlinal fold and to dip east and west of its axis at low angles. A tunnel has been driven into the ore-body for about 100 feet at the end of which the schists make a sudden plunge to the south. The section exposed may be divided into two zones: (1) an upper zone in which pyrrhotite predominates and (2) a lower one in which arsenopyrite is the principal ore mineral. Large lenses which owe their shape to the sliding of corrugated masses of rock over one another and almost horizontal veins filling cavities produced by compression (Figs. 2, 3 and 4) are well developed here. The ore, although it has not shown the phenomenal high values of some of the Mountain Top ore is more abundant and more evenly distributed through the rock-mass. The series of chlorite schists, of which this deposit is a member, has been traced over a wide area and at all its outcrops it is found to contain metalliferous ores. It is owned by the Richfield Mining Company, Limited, Halifax.

Galena.—"Galena," from a structural point of view is one of the most interesting and instructive of the L'Abîme deposits. It is situated in the L'Abîme gorge about 900 feet below the general level of the plateau and a mile N. N. E. of Iron Cap. It consists of a bed of garnetiferous serecite schist (locally called the "grey schist") carrying galena associated with zinc blende and arsenopyrite and outcropping in cliffs on both sides of the L'Abîme brook which here flows north-easterly. The schists are at this deposit bent into a synclinal fold with characteristic longitudinal and transverse undulations well developed. Several openings have been made on the right bank of the brook which facilitate the study of the structural features of the deposit. At these openings the prevailing dip is approximately N. N. W. at about 28°. Overlying the "grey" at the most westerly opening (No. 1) is a hydromica schist of bluish color (locally called the "blue schist") which is seen at the next opening towards the east to impinge upon and intertongue with the "grey" as the outcrop of the latter ascends the bank of the brook. Higher up the bank, but stratigraphically lower than it appears at No. 1 opening, the "grey" is seen intertongueing with the "blue." Lower down the brook in the cliff on the left bank, fragments of the "grey" are seen intercalated among the "blue." This faulted condition of the schists could only have been caused by a lateral thrust which broke and drove the severed beds over their original continuation and forced their jagged ends together. (See fig. 5.)

The ore minerals are found in lenses and veins in the "grey" schist in much the same manner as they occur in the deposits already described; but at Galena they are also found deposited in sheet-like masses along the thrust plane at the contact of the "blue," and "grey" schists. They are also found occupying rents of a somewhat lenticular shape which cut through the planes of foliation and which appear to have been formed at the time the thrusting took place.

The "blue" schist contains very little ore. It is a more compact and close-grained rock than the "grey" and does not appear to have been as much disturbed as the latter and fewer cavities were therefore developed for the reception of ore.

The thickness of the "grey" has not yet been determined as its base is nowhere exposed either by natural sections or the development work. From measurements taken in the slope, however, it would appear to be not less than 25 feet. This deposit is owned by the Cheticamp Gold Mining Company of Halifax.

Silver Cliff.—The most interesting structural feature of Silver Cliff—an argentiferous galena deposit situated on the L'Abîme brook about 1½ miles south of "Galena"—is the development of incipient secondary foliation by shearing—the rock splitting into thin corrugated slabs along planes perpendicular to those of stratification-foliation. The ore-bearing schist is here a chloritic variety which has been violently disturbed and severely plicated. It rests upon a corrugated sheet of white quartz, below which is seen a dark hornblendic rock (probably a diorite) which shows shistose structure but imperfectly developed. This deposit is owned by the Inverness Mining Company, Limited, of Halifax.

From the foregoing facts relating to the mode of occurrence of the L'Abîme ores, there would appear to be no doubt that the deposition of the ores took place *after* the formation had been folded, faulted and sliced, and not prior to, as has been reported, and that the ores were deposited along the lines of movement rather than along the planes of foliation or stratification and, therefore, while the beds of schist are faulted, it by no means follows that the ore bodies have been dislocated to any great extent.

METEOROLOGICAL NOTES.—BY F. W. W. DOANE, M. CAN. SOC. C. E., City Engineer, Halifax, N. S.

(*Read 16th May, 1905*)

The last notes read before the Institute in connection with precipitation ("Rainfall Notes," *Trans. N. S. I. S.*, vol. x, p. 399) recorded observations to December 31st, 1900. Since that date several new "records" have been noted.

RAIN.

The rainfall at Halifax for the month of June, 1901, is given by the Dominion Government Meteorological Agent at 6.959 inches, of which 4.099 inches fell on the 24th in 13.7 hours. This is not the heaviest rainfall on record as a reference to our *Transactions*, vol. ix, p. 282, shows that on Oct. 19th, 1896, 4.394 inches fell in 14.3 hours. The rate of fall is about the same in each instance, viz: .3 inches per hour. The maximum rate during the storm cannot be ascertained as automatic gauges are not provided.

The storm on June 24th, 1901, extended over a large area. It was very heavy, not only throughout Nova Scotia, but in the United States. The rain began about six o'clock in the morning and continued until after one o'clock. At 9 a. m. the gauge showed .33 inches. The figures given convey no idea to the average reader of the severity of the storm. During the greater part of the storm thunder roared, lightning flashed, the streets were deluged and torrents swept down the steep hills destroying the roadways. The rush of water carried down stones as large as a man's head and heaped up earth and road metal in mounds and ridges two feet high on the street railway

tracks. The sewers on some streets became surcharged so that the water spurted from the manholes to a height of several feet. Seldom has a continuous downpour lasted for so many hours.

The Director of the Observatory at St. John, N. B., reports a record-breaking thunder shower on July 15th, 1901, at the close of one of the hottest days of the season. The fall was .58 inches, nearly the whole of which fell in about 10 minutes. The Director estimates that during the greater portion of that time the fall exceeded the rate of $3\frac{1}{2}$ inches an hour. The measurements were made with an ordinary gauge as the observatory was not provided with an automatic register.

The total precipitation in Halifax in February, 1901, was .966 inches. The smallest fall previously recorded for that month was 1.61 in 1873. In May, 1903 only .676 inches fell the next smallest being 1.769 in May, 1894.

SNOW.

The winter of 1904-5 will long be remembered for its excessive snowfall. The first sleighs appeared on the streets of Halifax during the evening of December 13th and runners were in continuous service until March 27th.

Snowstorm followed snowstorm in rapid succession until streets, roads and railways were piled high, blockading traffic and paralyzing business. Each heavy storm was pronounced the worst by far for the past twenty to fifty years, yet each succeeding storm seemed worse than its predecessor.

In the city the street railway company managed to get their lines open after each storm, except in the western suburbs, the track from Coburg Road to Willow Park being snowed under on February 11th by a heavy gale and storm and remaining closed until April 5th. On portions of the main line the snow piled so high that the sweepers could not throw it clear and on some streets the track became walled in by four feet of packed

snow. Streets became impassable and teamsters were obliged to utilize the cleared sidewalks in order to reach their destination.

In the country, blizzard after blizzard blocked the railways until not a whee' turned for days on any line in Nova Scotia except on the Yarmouth to Barrington line. Slight thaws following the great falls of snow caused the water to lodge along the rails the snow preventing it from running off. Then frost came suddenly, the thermometer falling below zero and miles of rails became incased in a solid mass of ice, which could be removed only by the thaws of spring or the pickaxes of hundreds of men. The smaller roads succumbed during the first week in February, the heavy storm of January 31st having stolen a march on the "weather man" whose prediction was "fair and cold" and tied them up as completely as if they had never been completed.

Then on top of a month of snowstorms which had partially paralyzed railway communication in Nova Scotia and practically put an end to all trade between the capital and provincial points, came another storm, the severest of them all (Feb. 15-17). The Intercolonial Railway flyers were buried on Folleigh Mountain and the line to Sydney completely closed, through traffic not being in good working order again until the 27th. The Dominion Atlantic Railway was unable to get a train through from Halifax to Yarmouth until March 9th.

In Halifax business of all kinds suffered. The raging, howling blizzards sent blinding drifts sweeping in every direction. The milk train was cancelled for the first time since it became known as such and the condensed article sold at a premium. In order to relieve the tightness in the meat market two cattle dealers were obliged to bring their droves through on foot from Annapolis County. Funerals had to be postponed until the roads could be made passable. Buildings suffered from the depth and weight of snow on roofs which strained

them and caused them to leak and in some cases to collapse. Men, women and children moved about the streets on snow shoes.

Outside the city the conditions became even more serious, and places depending on the railway obtained relief none too soon. Hundreds of cars of freight were stalled along the Intercolonial Railway, numbers of locomotives were isolated, coal hoppers innumerable were imbedded in deep snow drifts, water gave out in stalled engines and trains were without heat, causing passengers to suffer much inconvenience and discomfort.

Schools, churches, electric light stations, foundries, &c., had to close. because wood could not be hauled and coal supplies were exhausted. Meat, flour, oil, butter, milk, eggs and feed became scarce. Farmers were obliged to destroy cattle and horses because they could not obtain hay and had difficulty in getting water for their stock. Lumbermen were forced to abandon their work in the woods in consequence of the depth of the snow.

In Windsor the water supply became short. In Sydney several departments of the steel works were compelled to shut down, being handicapped by the scarcity of cars and the impossibility of moving out their product and by the lack of fuel and other supplies buried deep in the monster snow drifts.

The administration of justice was interfered with, the presiding judge being unable to reach Sydney for the regular sitting of the supreme criminal court. The aid of the legislature was required to straighten out the tangle caused in this instance, parliament being in session.

The mail service was completely demoralized. Steamers were pressed into service between St. John, Yarmouth, Halifax and Sydney, while nearer towns, Windsor, Lunenburg, Bridgewater, &c., were reached by team before the railways could be dug out.

The loss to the province was enormous; trade being temporarily paralyzed, and the prices for supply of fuel, food and other necessaries increased rapidly as the stores decreased.

In olden times when snow fell deeply (but, perhaps never so deeply), and communication was wanted the roads were used, but in these days in winter only main roads are kept open, and when the snow falls deeply people stay at home or go by rail. In but few districts are supplies put in to last the winter through. The railways are depended on to provide from day to day or week to week. A winter such as that of 1904-5 demonstrates the extent to which the whole economic system of the country now hinges on the railways and how with all our progress we are still merely the plaything of the elements.

A call from the pulpits of Wolfville and Kentville brought volunteers to attack the ice and snow fetters of the Dominion Atlantic Railway. Professors, teachers and students from King's and Acadia Colleges, Horton Academy and Acacia Villa rendered valuable assistance in clearing the line, while ladies helped on the work by ministering to the wants of the laborers. The first train to Kentville after the disastrous blockade got through on February 27th with four cars of coal. The line to Sydney was opened on the 22nd, but the railway to Yarmouth (Dom. Atlantic Ry.) defied the best efforts of man until March 9th. Even after the railroads were opened snow continued to fall and drift into the cuttings, walled in by perpendicular banks of snow level with the roof of the cars. One incident reported in connection with the snow blockade on the Folleigh Mountain is worthy of note: A farmer who was working his weary way along a country road with a pair of horses and load of hay was stopped at a railway crossing by a 12 to 14 feet cut in the snow which had been opened by an Intercolonial Railway train leaving the sides perpendicular. The crossing problem was solved by backing the snow plow into the cut and driving the team over the bridge thus temporarily provided.

It was feared that the snow which, without rain or soft weather, had piled so high, would be melted by a rain storm when great loss would have resulted. Rivers would flow through the streets and along car tracks and sidewalks, flooding cellars, as few gutters or catchpits had been kept open. Bridges would have been carried away and roads and railways washed out, making transportation dangerous to life. Fortunately the sun did the work gradually and practically unaided, until the danger was passed and the great snows of 1904–5 had disappeared.

A comparison with past meteorological history shows that the past winter has been the worst snow winter on record. While it takes second place in total depth of snowfall, it takes first place in minimum depth of rainfall. In the winter of 1881-2 the snowfall (the deepest on record) was 124.72 inches and the rainfall for December, January, February, March and April, 20.543. In 1904-5 the figures are 123.92 and 9.959. While the difference in depth of snow is a fraction of an inch only, the difference in rainfall is over 10 inches. The snow falling in 1904-5 came in severe storms, and from December to March there was almost no rain and practically no thaw. The result was that the snow piled up to a greater height with each storm, while in an ordinary winter rains and thaws dispose of the surplus snow.

The accompanying tables show in detail the snow records since the establishment of the Government Meteorological Station at Halifax. A study of these tables shows that during the 36 years the heaviest snowfalls have occurred every 10 to 12 years, viz.: in the winters 1871-2, 1881-2, 1893-4 and 1904-5, the fall in the last three being practically the same. It may also be noted that there were at least three years in succession above the maximum.

As there have been two heavy years only this time, there may be another due in the winter of 1905-6.

Comparison with the precipitation of other years would also seem to indicate the possibility of a dry year in 1905. The last heavy snowfall, 1893-4, one of the greatest on record, was followed by the smallest rainfall.

Year.	*Rainfall only.*	*Total precipitation.*
1872	42.270	54.060
1882	47.610	62.022
1894	34.567	45.808

Acknowledgement is due to the Dominion Government Meteorological Agent at Halifax from whom valuable assistance was obtained in the preparation of this paper.

PRECIPITATION AT

YEAR.	1869.		1870.		1871.		1872.		1873.	
MONTH	Rain.	Snow.	Rain.	Snow	Rain.	Snow.	Rain.	Snow	Rain.	Snow.
January	3 040	14 0	5 180	14 9	2 380	14 7	2.580	13.1	4 780	26.6
February	3 200	8.4	6 820	29.6	4 110	19.3	2.400	19.3	0 490	10.7
March	4 110	29.3	1.640	14 4	4 390	15.1	0.760	43 0	2 460	15.5
April	2 210	2 7	3 780	.8	3 420	13 4	2 770	.8	1.930	6.5
May	5.510	5	3.190	T.	2 590	T	4 440	T	1.580	7.4
June	3 920	......	1 690	......	2 960	......	4.230	......	2 960	......
July	2 920	......	3 2[illegible]0	......	3 380	......	2.880	......	3.900	......
August	2 580	......	2 2[illegible]0	......	3 690	......	6 820	......	4.450	......
September	1.570	......	3.330	......	4.810	......	1 410	......	4.480	......
October	7 030	2.3	6 750	8	4 490	......	4 880	......	8.630	......
November	5 190	3.5	5.670	7.7	3.210	10 0	6 230	4.4	7 400	5.8
December	5.140	4.8	4.810	10 7	1 880	24 8	2.870	32.3	2.210	18.9
Totals	46.420	65.50	48.270	78.9	41 310	97 3	42 270	112.9	45 270	91.4
Total Precipitation	54 530		56.160		51.140		54.060		55.440	

YEAR.	1880.		1881.		1882.		1883.		1884.	
MONTH.	Rain.	Snow	Rain.	Snow	Rain.	Snow.	Rain	Snow	Rain.	Snow.
January	5.393	23.4	2.737	8 7	3 160	36.80	2 400	25 30	3.616	7.90
February	3.242	18 8	2.939	23 9	1.672	42.77	2.428	14.32	4.701	14.60
March	1 015	23.5	5.915	6.4	5.458	16.10	3 641	13.00	3.814	32 20
April	4.097	7.0	3.236	2.6	3.679	11.45	2.933	7.70	6.895	3.18
May	4.088	......	2.460	......	4.677	......	8.613	......	3.629	......
June	1.343	......	5 301	......	5.507	......	3.3 2	......	3.773	......
July	3 086	......	3 177	......	5 071	......	3.510	......	8.294	......
August	3.920	......	3 062	......	3.925	......	5.342	......	2.771	......
September	5 712	......	3.105	......	5.914	......	3.864	......	1 788	......
October	4.590	......	4.206	......	7.403	......	5.841	......	3.083	0.10
November	4.344	3.6	3.120	13.0	0.832	5 60	2.628	8 50	5 652	3.40
December	3.213	11.8	6.574	4.6	1 312	21.40	4.008	26.70	7.416	17.08
Totals	44.043	88.1	45.832	59.2	47.610	134.12	48.560	95 5	55.432	78.46
Total Precipitation	52.853		51.755		62 022		58.112		63.278	

YEAR.	1891.		1892.		1893.		1894.		1895.	
MONTH.	Rain	Snow.	Rain	Snow.	Rain.	Snow	Rain.	Snow	Rain.	Snow.
January	6.099	22.84	5 339	9 82	3.10	16.80	1.732	53.90	7.321	28.10
February	6.940	18.00	0.845	17.60	2.21	37.60	2 871	7.00	1.223	33 82
March	1.567	11.18	4 433	15.53	1.73	5.60	1.723	19.00	3 963	19.68
April	3.528	4.82	2.480	1.73	3.63	5.80	3.422	22.26	3 896	.60
May	4.195	......	5.459	......	5 05	......	1.769	......	4 089	......
June	4.131	......	3.638	......	1.75	......	3.803	......	1 827	......
July	4.003	......	2.710	......	4.75	......	1.059	......	3.924	......
August	3.385	......	6.809	......	5.95	......	3.993	......	5.502	......
September	3.052	..	1.744	......	4.39	......	1.010	......	2 491	......
October	9.616	0 05	3 472	......	5.64		3.863	......	5.437	1.90
November	2.388	...	9.240	......	3.60	1.50	5.422	3.63	8.223	......
December	3 984	0 92	2.352	7.01	8.15	20.10	3.900	6.62	5 519	2.97
Totals	52.888	57 81	48.521	51.69	49.98	87.60	34.567	112.41	53 445	87.07
Total Precipitation	58.669		53.690		58.74		45 808		62.152	

HALIFAX, N. S., 1869-1905.

1874.		1875.		1876.		1877.		1878		1879.	
Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.
3.800	15.7	0.610	28.71	1 341	21.10	0.840	33.10	6.987	5 35	0.070	43 30
2 280	29.9	2.929	29 68	3 133	33.23	1 024	7.90	1 977	7.20	0.631	23.70
3.630	3 7	0 711	14.02	5.774	5 60	7.428	12.3	9.489	7.95	5.082	11.20
1 900	26.5	2.958	4.20	2 130	9.95	3.621	1.70	3.476	0.26	2.291	11.90
4.760	0.1	3.977	......	4 574	0 90	4.024	......	5 759	......	4.687	......
7 920	......	4.067	......	3.381	......	3.841	......	4.477	......	1.191	......
2.290	......	5.612	......	3.914	......	4 468	......	1.483	......	3.843	......
3.370	......	3 555	......	1.909	......	3.539	......	3 127	......	4.827	......
5 040	......	2.060	......	6.094	......	3.164	......	0.890	......	2.596	......
2.460	......	9.976	......	4.067	0.01	6 623	0.90	5.061	......	4.755	T
3.370	2.1	5.154	3.90	7.397	T	8.678	......	6.853	0.56	2.997	18.26
4.420	11.0	0 884	7.30	0.618	25.58	3.027	14.40	4.281	8.38	2 179	18 50
45.240	89 0	42.493	87.81	44.335	96.37	50 277	70 30	53 770	29.70	35.149	126.86
54.180		51.274		53.972		57.510		56 740		47.835	

1885.		1886.		1887.		1888.		1889.		1890.	
Rain.	Snow.	Rain	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain,	Snow.
3 928	24.60	8.030	6.40	5.320	23 80	2.862	25.80	4.041	3.5	1.480	24.80
1.820	32.70	2.162	16.80	4.633	21.02	5.304	9.80	4.931	12 5	2.946	16.99
1.649	22.40	1.837	21 90	2.539	19.10	3.770	5.40	1.576	4.7	8 543	13.46
3 470	0.50	0.443	3.80	5 838	05.58	2.455	12.20	6 510	8.93	2.598	3.60
3.282	......	8.819	......	2.126	......	2.857	.20	3.871	......	3.970	......
2 749	......	2.708	......	2 121	......	4.939	......	3.755	......	3.440	......
5 817	......	6 525	......	2.045	......	5.001	......	2 668	......	2.141	......
3.001	......	4.526	......	8 351	......	7.000	......	2 663	......	7 042	......
2.497	......	4.459	......	3.308	......	5.331	......	1.399	......	4.534	......
6.280	......	2 105	0.30	3 058	......	6.859	......	4.179	......	6.603	......
5.383	0.40	5.204	0 80	6.718	T	6.772	.30	6.995	1.5	3.596	1.20
7.393	13.00	4.149	13.20	3.618	5 02	7.761	.10	2.708	2.8	6.082	11.20
47.269	93.60	50.967	63.20	49 681	74.52	60.914	53.80	45.266	33.93	52.978	71.25
56 629		57.287		57.133		66 291		48.659		60.103	

1896.		1897		1898.		1899.		1900.		1901.	
Rain	Snow	Rain.	Snow.	Rain.	Snow	Rain	Snow.	Rain.	Snow.	Rain.	Snow.
0.260	14.60	3.433	24.63	2.370	16 90	3.943	11.40	7.582	9.5	3.503	32.4
1.852	23.47	0.744	21 54	2.444	19.78	1.333	22.80	4.677	6.0	.060	9.0
7.238	15.48	3.852	16 18	2.718	13.50	5.445	17.33	5 345	5.7	3.043	5.3
1.108	3.05	5.443	7.68	6.752	5.94	2.908	3.70	3 289	5.3	6.235	.8
2.532	......	4.591	0 22	2.366	......	3.657	0.20	4.234	......	5.556	......
4.671	......	6.070	......	5.598	......	3 875	......	2.676	......	6.959	......
8.729	......	3.661	......	3.652	......	5.747	......	1.872	......	1.585	......
3.037	......	5.185	......	5.651	......	1.542	......	3.993	......	3.656	......
12 092	......	1.169	......	4.158	......	3 201	......	5.043	......	6.872	......
15.039	..	0.746	......	4.845	......	6.191	......	7.365	......	4.884	......
3.439	9 57	5 961	0.90	9.881	3.67	4.460	1.20	6.370	4.1	2.558	......
2.618	6.30	3.356	1.86	2.329	17.37	3.166	18.72	1.276	19.8	5.483	30.9
62.615	72 47	44.221	73.01	52.764	77.16	45.468	75.45	53.702	50.4	50 394	78.4
69.862		51.522		60.480		53.013		59.697		58.096	

PRECIPITATION AT HALIFAX, N. S., 1869-1905—*Continued.*

YEAR.	1902.		1903.		1904.		1905.	
MONTH	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.	Rain.	Snow.
January	2.055	11.3	3.432	13 7	3 548	23 80	3.630	46.60
February	1.290	11 5	2.022	16.9	2 278	31.50	1.586	37 40
March	7.757	.....	6.474	6.1	4 602	9.60	1.644	11.60
April	2.487	5 8	5.403	.8	4.992	15.20	1.240	.02
May	3.725	......	.676	......	3.315	......	......	......
June	4.908	....	3.493	......	2.668	....	.....	....
July	1.651	....	4.313	....	2.332	.....	......	.....
August	4.767	.....	4.247	....	6.520	.....	....	......
September	4.657	......	4.237	.....	4.502	......	.....	....
October	4.252	....	6 368	......	5.031	.....	.....	.....
November	3.813	....	9.228	3.7	5 007	1.00	.....	......
December	4.853	21.3	3 210	13.8	1.859	27.30	....	......
Totals	46.215	49.9	53.103	55.0	46 654	108.40	......	.....
Total Precipitation	51.916		59 125		57.494		.....	

NOTE.—In the preceding tables "T" indicates *Trace.*

SNOWFALL AT HALIFAX DURING EACH WINTER, 1869-1905.

Winter of	October.	November.	December.	January.	February.	March.	April.	May.	Total Snowfall.
1869-70	2.3	3.5	4 8	14.9	29.6	14.4	0.8	T	70 30
1870-71	0 8	7.7	10.7	14.7	19.3	15.1	13.4	T	81 70
1871-72	....	10 0	24 8	13.1	19.3	43.0	0.8	T	111.00
1872-73	...	4 4	32.3	26.6	10 7	15.5	6 5	7.4	103.40
1873-74	....	5 8	18 9	15.7	29.9	3.7	26.5	0.1	100.60
1874-75	....	2 1	11.0	28 71	29.68	14.02	4.2	....	89.71
1875-76	....	3.9	7 3	21.1	33 23	5.60	9.95	0.9	81.98
1876-77	0.01	T	25.58	33.10	7.90	12.30	1.70	....	80.59
1877-78	0.90	....	14 40	5.35	7.20	7.95	0.26	....	36.06
1878 79	....	0 56	8.38	43.30	23.70	11.20	11 90	....	99 04
1879-80	T	18.26	18 50	23.40	18 80	23 50	7.00	....	109.46
1880-81	...	3.60	11.80	8 70	23.90	6.40	2 60	....	57.00
1881-82	....	13.00	4 60	36 80	42.77	16.10	11.45	....	124 72
1882-83	....	5.60	21.40	25.30	14.32	13 00	7.70	....	87.32
1883-84	....	8 50	26 70	7 90	14.60	32 20	3.18	....	93.08
1884-85	0 10	3.40	17.08	24.60	32.70	22.40	0.50	....	100 78
1885-86	....	0.40	13.00	6.40	16.80	21.90	3 80	....	62.30
1886-87	0 30	0.80	13 20	23.80	21.02	19.10	5.58	...	83.80
1887-88	....	T	5 02	25.80	9 80	5.40	12.20	0.20	58.42
1888-89	. ..	0.30	0.10	3.50	12 50	4 70	8.93	....	30.03
1889-90	....	1.50	2 80	24.80	16.99	13 46	3 60	....	63.15
1890-91	....	1 20	11.20	22.84	18.00	11.18	4 82	....	69.24
1891-92	0.05	....	0.92	9.82	17.60	15 53	1.73	...	45.65
1892-93	....	...	7.01	16.80	37.60	5 60	5 80	....	72 81
1893-94	....	1.50	20.10	53.90	7 00	19 00	22 26	....	123.76
1894-95	....	3.63	6.62	28 10	33.82	19.68	0 60	....	92.45
1895-96	1.90	....	2 97	14.60	23.47	15.48	3.05	....	61.47
1896-97	....	9.57	6.30	24.63	21.54	16.18	7 68	0.22	86 12
1897-98	....	0.90	1.86	16.90	19.78	13.50	5.94	....	58.88
1898-99	....	3.67	17.37	11.40	22 80	17.33	3 70	0 20	76.47
1899-00	....	1.30	18.72	9 50	6.00	5.70	5 30	....	46.52
1900-01	....	4.10	19.80	32 40	9.00	5.30	0.80	....	71.40
1901 02	....	....	30.90	11.30	11.50	....	5.80	....	59.50
1902-03	....	....	21.30	13 70	16.90	6.10	0.80	....	58 80
1903-04	....	3.70	13.80	23 80	31.50	9.60	15.20	....	97 60
1904-05	...	1.00	27.30	46.60	37 40	11.60	0.02	...	123.92

Comparison of Snowfall at Halifax, N. S.
(36 years).

Month.	Maximum. Inches.	Maximum. Year.	Minimum. Inches.	Minimum. Year.	Mean Inches.	1904-5.	Remarks.
October	2.30	1869	0.010	1876	0.18	.....	Fall in nine years only.
November	13.00	1881	0.300	1888	3.44	1.0	In 6 years no fall recorded.
December	32.30	1872	0.100	1888	13.85	27.3	
January	53.90	1894	3.500	1889	21.22	46.6	
February	42.77	1882	6.000	1900	20.80	37.4	
March	43.00	1872	3.700	1874	13.68	11.6	No fall in 1902.
April	26.50	1874	0.260	1878	6.28	0.02	Fall recorded in every year.
May	7.40	1873	0.100	1874	0.25	.....	Fall in nine years only.

Maximum snowfall in one year ..			134.12 in 1882.
Minimum	"	"	29.70 in 1878.
Mean	"	36 years ..	78.53.
Mean	"	one winter ..	79.70.
Maximum	"	one winter ..	1881-2, 124.72—56% above mean.
			1904-5, 123.92—55% "
			1893-4, 123.76—55% "
			1871-2, 111.00—39% "
Minimum	"	one winter .	1888-9, 30.03—38% "
Maximum	"	two winters.	1903-5, 221.52 aver 110.76—39% above mean
			1893-5, 216.21 " 108.11—36% "
			1871-3, 214.40 " 107.20—35% "
			1881-3, 212.04 " 106.02—35% "
Maximum	"	three winters.	1871-4, 315.00 " 105.00—32% "
			1881-4, 305.12 " 101.70—28% "
			1892-5, 289.02 " 96.34—20% "
			1902-5, 280.32 " 93.44—16% "

Rainfall (*only*) at Halifax, N. S., during Winters of Greatest Snowfall.

Winter	December.	January.	February.	March.	April.	Total for Dec., Jan., Feb., March, Apl.	Total for Jan., Feb., March, Apl.
1871-2..	1.88	2.58	2.4	0.76	2.77	10.39	8.51
1881-2...	6.574	3.16	1.672	5.458	3.679	20.543	13.969
1893-4...	8.15	1.732	2.871	1.723	3.422	17.898	9.748
1904-5...	1.859	3.63	1.586	1.644	1.24	9.959	8.100

Phenological Observations in Nova Scotia and Canada, 1904.—By A. H. MacKay, ll. d., f. r. s. c., Halifax.

(Read 16th May, 1905).

In Nova Scotia the public schools have been doing good work in phenology. Over three hundred accurate and full schedules of observations were sent in from as many school sections representing every county in the province. These were referred in groups to the following phenological staff for examination, selection, and compilation; and the criticisms on faulty observations were published in the *Journal of Education* for the benefit of observers in future years—from page 72 to 85 of the April issue, 1905.

Region I. (Yarmouth and Digby), A. W. Horner, Principal, Salem School, Yarmouth.

" II. (Shelburne Co.), C. Stanley Bruce, Principal, Academy, Shelburne.

" II. (Queens Co.), Miss M. C. Hewitt, Science Teacher, Academy, Lunenburg.

" II. (Lunenburg Co.), B. McKittrick, B. A., Principal, Academy, Lunenburg.

" III. (Annapolis and Kings), E. Robinson, Principal, Academy, Kentville.

" IV. (Hants Co.), Miss A. Forbes, B. A., Academy, Windsor.

" V. (Halifax Co.), G. R. Marshall, B. A., Principal, C. A. School, Halifax.

" V. (Guysboro Co.), J. B. McCarthy, B. Sc., Science Master, Academy, Halifax.

" VI. (Colchester and Cumberland), J. E. Barteaux, Science Master, Academy, Truro.

" VII. (N. Cumberland Co.), E. J. Lay, Principal, Academy, Amherst.

" VII. (Pictou Co.), W. P. Fraser, Science Master, Academy, Pictou.

" VII. (Antigonish Co.), F. G. Morehouse, Principal, Schools, Antigonish.

" VIII. (Richmond Co.), G. W. MacKenzie, B A., Principal, Public Schools, Sydney Mines.

" VIII., IX., X. (Cape Breton, Victoria and Inverness Co.), L. A. DeWolf, M. Sc., High School, North Sydney.

The phenochrons of each of these compilers were again averaged into the ten columns of phenochrons for each region of the province by Miss Jean Lindsay, B. A., of the Education Department, as they are given in the first table following.

The general phenochrons for Nova Scotia, and the observations reported by the following observers from stations within the other provinces of the Dominion are given in the last table :

New Brunswick : George U. Hay, D. Sc., Saint John.

Prince Edward Island : John MacSwain, Charlottetown.

Prince Edward Island : J. M. Duncan, Kensington.

Ontario : Cephas Guillet, Ph. D., Ottawa.

Ontario : Mrs. F. E. Webster, Creemore.

Ontario : A. B. Klugh, Guelph.

Saskatchewan : Rev. Charles W. Bryden, B. A., Shellbrook.

British Columbia : J. K. Henry, B. A., Vancouver.

These tables were published in the *Proceedings of the Royal Society of Canada* ; and as two or three errors have since been detected in figures in the first table referring to Nova Scotia under Nos. 48 and 79b, they are corrected herein.

NOVA SCOTIA PHENOCHRONS, 1904.

Flowering and other Phenochrons for each Region of the Province of Nova Scotia, compiled from 300 Public School Observation Schedules.

[*The Phenochrons for each region, (which are the averages of many observations), have the fractions omitted*].

Year ended July, 1904, Nova Scotia.

Day of the year corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec	365

For leap year add one to each except January.

When First Seen. — Region.

No.	Species	1. Yarmouth and Digby.	2. Shelburne, Queens, and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6 South Cobequid Slope (S. Cumb and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria).	10. Inverness Slope to Gulf.	Average for Province.
1	Alnus incana, Willd	102	101	98	110	114	103	107	112	109	108	196 9
2	Populus tremuloides	115	112	109	119	129	120	115	119	119	125	118.
3	Epigaea repens, L	92	98	99	103	113	115	113	115	117	121	109.1
4	Equisetum arvense	125	127	132	126	134	133	128	132	121	125	128.8
5	Sanguinaria Canadensis	....	....	...	121	132	130	130		124	126	127.5
6	Viola blanda	120	121	125	125	126	126	127	130	129	129	126 3
7	Viola palmata, cucullata	124	126	126	127	136	128	129	134	133	133	130.
8	Hepatica triloba, etc	...	126	113	129	...	123	118	124	...	....	122.3
9	Acer rubrum	127	127	124	126	131	127	127	132	128	136	128.8
10	Fragaria Virginiana	122	124	123	123	130	127	129	133	132	131	127.7
11	" " fruit ripe	158	159	157	158	152	161	164	168	170	168	161 9
12	Taraxacum officinale	125	127	127	128	133	133	132	136	134	137	131.6
13	Erythronium Americanum	139	140	138	131	156	128	130	137	....	...	137.7
14	Coptis trifolia	125	129	132	132	132	133	134	137	137	137	133 2
15	Claytonia Caroliniana	124	125	130	125	131	126	128	128	129	133	128 1
16	Nepeta Glechoma	....	137	137	131	139	135	141	138	143	141	138 4
17	Amelanchier Canadensis	137	136	135	136	142	135	136	144	146	141	137 1
18	" " fruit ripe	....	198	180	....	240	216	195	185	203	182	200 1

When Becoming Common. — Region.

No.	Species	Average for Province.	1. Yarmouth and Digby.	2. Shelburne, Queens, and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria).	10. Inverness Slope to Gulf.
1	Alnus incana, Willd	113 2	108	108	103	115	121	114	112	119	114	113
2	Populus tremuloides	124.3	127	118	117	128	131	125	121	124	123	127
3	Epigaea repens, L	118 1	107	109	108	116	119	124	121	123	123	127
4	Equisetum arvense	135.2	135	131	137	131	145	139	134	136	124	135
5	Sanguinaria Canadensis	130 8	126	....	....	128	138	130	132		128	133
6	Viola blanda	132.6	127	128	134	130	134	132	133	135	133	136
7	Viola palmata, cucullata	135.3	130	131	133	133	138	134	136	139	136	139
8	Hepatica triloba, etc	127 5	...	137	120	134	..	123	120	130	....	....
9	Acer rubrum	133.1	131	132	131	132	127	131	132	138	132	140
10	Fragaria Virginiana	136.6	131	133	132	132	144	135	137	140	137	141
11	" " fruit ripe	173.3	172	169	169	169	175	172	175	177	179	176
12	Taraxacum officinale	138.	133	134	134	131	140	139	139	141	140	143
13	Erythronium Americanum	141.8	146	146	148	137	147	133	136	130	...	....
14	Coptis trifolia	139.	132	136	140	138	139	137	139	144	140	142
15	Claytonia Caroliniana	132.1	131	129	136	128	125	131	131	132	134	140
16	Nepeta Glechoma	143 6	141	142	145	136	143	142	149	141	146	146
17	Amelanchier Canadensis	144.8	141	144	143	141	148	140	141	150	149	146
18	" " fruit ripe	217.9	...	214	....	....	246	223	214	...	221	199

NOVA SCOTIA PHENOCHRONS, 1904.—*(Continued)*.

WHEN FIRST SEEN. — REGIONS. 1. Yarmouth and Digby.	2. Shelburne, Queens, and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Picton and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria).	10. Inverness Slope to Gulf.	Average for Province.	YEAR ENDED JULY, 1904, NOVA SCOTIA.		WHEN BECOMING COMMON. — Average for Province.	REGIONS 1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Picton and Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. and Victoria).	10. Inverness Slope to Gulf.
138	141	141	142	151	138	141	151	151	149	144 5	19	Prunus Pennsylvanica	149.5	143	147	146	146	153	143	146	158	154	155
180	209	..		243	216	212	225	225	...	215.9	20	" " fruit ripe	223.	190	216	...	...	247	221	220	236	230	....
131	134	136	139	143	140	142	148	149	151	141 7	21	Vaccinium Can. and Penn	148 7	139	142	143	145	152	146	148	156	153	159
178	189	191	194	232	223	205	. .	222	231	207 6	22	" " fruit ripe	222.7	204	217	216	203	240	224	218	236	227	240
139	144	140	143	149	144	146	154	155	158	147 5	23	Ranunculus acris	155.5	148	150	151	151	157	154	155	160	159	165
147	151	152	150	168	150	159	162	163	163	156.9	24	R. repens	162.3	152	158	158	163	159	162	163	168	167	170
141	145	143	143	147	140	143	155	147	153	145.9	25	Trillium erythrocarpum	151.1	148	146	149	149	156	144	148	157	150	160
138	141	143	141	146	142	144	153	149	151	145 1	26	Rhododendron Rhodora	153.6	150	147	148	145	153	147	149	155	153	154
143	145	145	146	144	143	147	152	151	152	147.2	27	Cornus Canadensis	150.5	150	151	153	153	153	149	152	157	156	157
182	201	205	247	220	216	205	. .	210	225	212 6	28	" " fruit ripe	220.	204	217	210	253	202	224	219	..	215	231
146	144	144	146	148	149	147	153	154	149	148.5	29	Trientalis Americana	154.2	150	150	150	153	156	154	154	157	159	154
147	150	150	143	156	152	151	126	156	155	15'.5	30	Clintonia borealis	157.5	153	168	156	151	165	156	157	157	162	158
159	150	162	147	159	159	159	161	....	168	158.5	31	Calla palustris	165.4	178	155	....	150	165	165	163	172	....	174
150	151	152	154	159	155	155	167	167	...	157.1	32	Cypripedium acaule	162.4	156	158	158	159	163	162	159	171	171	....
151	152	154	149	159	159	159	162	163	167	158	33	Sisyrinchium angustifolium	164.7	158	158	163	156	166	167	165	170	167	172
154	156	159	157	163	164	162	167	171	172	162 9	34	Linnæa borealis	168	161	163	166	164	167	167	169	170	176	174
148	148	148	146	154	145	149	155	156	157	151.1	35	Kalmia glauca	156.6	149	154	154	151	167	151	156	158	158	163
159	166	166	167	163	174	169	174	180	179	170.1	36	Kalmia angustifolia	174.3	166	174	173	176	162	176	174	179	186	. ..
158	155	157	155	163	170	157	170	...	170	162.	37	Cratægus oxyacantha	167,3	162	162	165	164	167	171	162	177	...	172
157	150	152	153	158	158	151	164	166	165	157 7	38	Cratægus coccinea, etc	163.	165	159	158	154	163	165	159	167	169	168
158	157	162	160	167	161	163	170	170	173	164 6	39	Iris versicolor	170.3	164	163	170	164	173	167	170	176	174	177
159	158	159	160	169	161	161	172	171	172	164.8	40	Chrysanthemum Leucanthemum.	171.4	163	167	167	169	165	170	169	175	178	176

Day of the year corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
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June	181	Dec	365

For leap year add one to each except January.

161	159	163	157	166	165	163	169	170	170	164.9	41	Nuphar advena	170 5	170	165	170	165	170	172	170	174	173	173
156	155	158	150	161	156	163	160	169	167	160.6	42	Rubus strigosus	166.9	162	162	166	161	167	160	168	171	173	173
236	195	206	....	230	217	206		222	226	217.5	43	“ ” fruit ripe	227.1	220	219	216	225	236	227	238	..	227	234
164	172	170	171	175	....	173	173	175	179	172.7	44	Rhinanthus Crista-galli	175.9	172	176	180	177	180	153	181	176	180	181
162	165	162	159	165	159	167	172	171	175	166.	45	Rubus villosus	171.6	167	171	169	164	170	165	174	176	178	177
227	227	232	246	241	241	240	....	239	262	239.7	46	“ ”	249.2	236	253	239	252	247	252	249	....	244	268
165	161	151	168	176	169	169	174	177	.	168.1	47	Sarracenia purpurea	172.1	171	167	167	....	153	175	175	180	187	....
171	170	170	175	181	155	174	178	182		173 3	48	Brunella vulgaris	177.7	178	175	178	178	...	165	178	181	186	....
173	174	178	174	193	173	176	187	187	181	179.9	49	Rosa lucida	181.6	180	178	182	180	184	179	181	176	192	....
159	162	168	164	166	166	167	172	170	179	167.6	50	Leontodon autumnale	173.7	170	168	175	170	175	172	177	177	174	....
167	176	172	175	..	169	181	190	..	..	176.	51	Linaria vulgaris	178.6	167	182	179	179	..	176	174	191	..	
138	135	135	132	140	132	133	140	140	139	136.8	52	Trees appear green	146.	141	145	145	139	150	141	143	153	149	146
136	140	138	137	143	140	139	149	148	142	141.8	53	Ribes rubrum (cultivated)	147.2	141	146	146	143	150	144	144	152	153	148
181	179	...	....	230	205	194	....	208	226	203 4	54	“ ” (fruit ripe)	211.1	194	199	....	191	238	215	212		209	230
139	142	139	140	145	142	140	148	149	141	142.9	55	R. nigrum (cultivated)	148.1	143	147	145	146	151	146	147	154	151	147
190	199	...	....	219	214	201	....	213	228	209.4	56	“ (fruit ripe)	214.9	195	205	...	...	210	223	214	...	218	239
138	144	138	142	160	146	146	152	155	148	147.4	57	Prunus Cerasus	156.9	145	151	145	149	163	150	151	157	160	155
221	199	..	200	...	212	205	218	214	....	210.	58	“ ” fruit ripe	210.3	228	206	150	220	...	219	214	225	220	....
141	147	142	144	157	147	147	156	160	156	151.1	59	Prunus domestica	155.8	145	152	147	150	169	150	152	163	164	162
143	146	143	144	155	147	147	161	159	155	150.5	60	Pyrus Malus	155.7	151	152	150	151	161	152	148	165	163	159
151	153	152	151	160	153	153	167	162	170	157.6	61	Syringa vulgaris	163.6	158	159	158	157	168	160	160	171	167	174
150	156	156	152	157	151	156	162	161	167	157.3	62	Trifolium repens	165.3	159	163	167	159	166	160	165	168	168	173
144	151	154	150	157	153	156	161	162	164	155.7	63	Trifolium pratense	164.6	154	159	163	160	166	162	166	168	171	172
173	169	171	173	171	164	167	184	196	..	157.2	64	Phleum pratense	180.6	180	173	178	180	180	175	177	180	199	..
175	181	184	205	...	197	190	....	199	181	176.8	65	Solanum tuberosum	198.7	189	189	196	222	...	208	201	181	204	193
104	114	115	124	118	124	126	120	125	119	119.3	66	Ploughing (first of season)	126.8	116	123	125	132	124	...	132	129	131	126
122	121	124	129	126	130	131	131	136	130	128.4	67	Sowing “ ”	135.9	130	129	135	138	132	....	138	137	143	137
119	118	123	129	125	131	132	125	129	131	126.6	68	Potato-planting (first of season)	134.4	125	129	144	141	128	....	138	132	134	136
143	129	117	136	127	138	135	129	123	114	129.6	69	Sheep-Shearing “	138 7	150	138	131	148	140	....	115	136	131	127
186	180	191	215	214	223	203	215	213	213	205.7	70	Hay-cutting “	211.	192	186	202	226	218	....	209	225	218	220
239	239	239	250	253	250	245	262	255	247	248.3	71	Grain-cutting “	256.4	252	247	249	258	253	...	257	271	264	254
248	263	254	270	273	264	272	269	276	269	266.2	72	Potato-digging “	272.2	256	276	270	276	257	...	278	281	274	278
81	81	80	80	92	94	91	91	91	100	88.5	73a	Opening of rivers	.....	...	...	..	..	...	..	..	..	...	....
93	96	97	102	112	112	105	119	119	113	107.1	73b	Opening of lakes	.....	....	...	..	....	...	...	....	...	....	....
111	111	111	115	111	114	110	109	112	114	112.2	74a	Last snow to whiten ground	.....	....	..	..	....	...	...	....	...	....	...
111	111	112	118	118	119	117	123	122	129	118.4	74b	“ to fly in air	.....	....	..	..	....	...	...	...	...	...	...
134	135	141	133	132	155	139	145	134	137	138.9	75a	Last Spring frost—hard	.....	....	...	....	....	...	.	....	...	....	...
158	163	166	150	160	161	157	159	163	157	159.8	75b	“ “ hoar	...		...	...	....	...	...	....	...	....	...
....	104	90	127	167	86	97	103	100	110	102.5	76a	Water in streams—high	.....	....	....	...	....	..	..	...	...	...	...
183	187	..	181	181	200	...	180	243	194	186.8	76b	“ “ low	.....	..	...	..	...	..	...	...	...	...	...
272	257	240	257	276	258	271	285	325	275	271.9	77a	First autumn frost—hoar	.....	...	...	...	...	....	...	....	....	...	...
297	292	277	294	297	289	295	300	314	304	296.3	77b	“ “ hard	.....	....	...	...	...	...	...	..	..	...	....
295	299	298	298	302	299	3 0	297	314	290	299.6	78a	First snow to fly in air	...	...	..	...	...	...	...	....	...	...	....
305	311	304	310	320	299	305	310	316	299	308.3	78b	“ to whiten ground	...	...	..	...	...	...	...	....	...	...	...
332	338	342	332	...	335	348	348	353	353	342.5	79a	Closing of lakes	.....	...	...	...	..	...	...	...	...	...	...
...	354	...	341	347	365	348	357	359	354	353.4	79b	“ rivers	.....	...	...	..	...	...	...	...	...	...	...
....	86	86	80	84	96	89	90	91	90	88.3	80a	Wild Ducks migrating, N	...	...	...	...	...	...	...	...	...	...	...

NOVA SCOTIA PHENOCHRONS, 1904 —(*Continued*).

Year ended July, 1904. Nova Scotia.

Day of the year corresponding to the last day of each month.

Jan	31	July	212
Feb	59	Aug	243
March	90	Sept	273
April	120	Oct	304
May	151	Nov	334
June	181	Dec	365

For leap year add one to each except January.

When First Seen — Regions: 1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col).	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton	9. Bras d'Or Slope (Inv and Victoria	10. Inverness Slope to Gulf.	Average for Province.	No.	Phenomenon	When Becoming Common — Average for Province.	1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. South Cobequid Slope (S. Cumb. and Col.)	7. North Cumb., Col., Pictou and Antig.	8. Richmond and Cape Breton	9. Bras d'Or Slope (Inv. and Victoria).	10. Inverness slope to Gulf.
...	298	298	243	....	287	312	270	350	306	295.7	81b	Wild Ducks migrating, S	...	...	...	...	...	...	...	...	...	...	...
81	85	84	78	82	85	81	82	86	85	83.9	82a	Wild Geese migrating, N	...	...	...	...	...	...	...	...	...	...	...
317	283	336	324	.	337	315	283	303	....	312.5	82b	" " S	...	...	...	...	...	...	...	...	...	...	...
85	83	88	87	88	97	92	93	96	98	91.2	83	Melospiza fasciata, North	...	...	...	...	...	...	...	...	...	...	...
82	84	83	85	85	87	90	90	90	99	88.1	84	Turdus migratorius "	...	...	...	...	...	...	...	...	...	...	...
70	88	81	89	86	94	91	85	92	94	87.3	85	Junco hiemalis "	...	...	...	...	...	...	...	...	...	...	...
....	108	132	124	121	130	134	138	131	125	127.4	86	Actitis macularia "	...	...	...	...	...	...	...	...	...	...	...
...	114	....	128	...	116	121	126	124	....	121.7	87	Sturnella magna "	...	...	...	...	...	...	...	...	...	...	...
129	122	126	125	117	127	123	125	126	125	124.9	88	Ceryle Alcyon "	...	...	...	...	...	...	...	...	...	...	...
29	141	....	128	135	140	136	130	....	134	134.5	89	Dendrœca coronata "	...	...	...	...	...	...	...	...	...	...	...
137	136	139	140	115	142	135	136	126	137	134.6	90	D. æstiva "	...	...	...	...	...	...	...	...	...	...	...
124	120	110	130	133	120	110	119	116	107	119.4	91	Zonotrichia alba "	...	...	...	...	...	...	...	...	...	...	...
151	147	143	141	150	143	143	149	142	143	145.6	92	Trochilus colubris "	...	...	...	...	...	...	...	...	...	...	...
138	138	136	136	139	136	138	151	141	144	140.1	93	Tyrannus Carolinensis, North	...	...	...	...	...	...	...	...	...	...	...
138	143	137	133	115	121	138	141	131	139	133.8	94	Dolychonyx oryzivorus "	...	...	...	...	...	...	...	...	...	...	...
148	144	143	139	142	150	146	146	132	..	143.7	95	Spinis tristis "	...	...	...	...	...	...	...	...	...	...	...
....	141	134	142	100	153	139	140	134	150	137.3	96	Setophaga ruticilla "	...	...	...	...	...	...	...	...	...	...	...
117	133	..	148	....	138	153	....	131	....	142.	97	Ampelis cedrorum "	...	...	...	...	...	...	...	...	...	...	...
102	132	128	125	124	139	129	117	..	105	122.5	98	Chordeiles Virginianus "	...	...	...	...	...	...	...	...	...	...	...
95	97	99	107	115	110	108	115	118	117	108.7	99	First piping of frogs	...	...	...	...	...	...	...	...	...	...	...
104	107	108	116	120	122	119	120	120	120	116.2	100	First appearance, snakes	...	...	...	...	...	...	...	...	...	...	...

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, NOVA SCOTIA, 1903.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.	Province of Nova Scotia. YEAR 1903.
....	183^{3}	....	....	183	183	183^{13}	....	....	....	183^{18}
184	....	....	184	184^{2}	....	184^{10}	....	....	184	184^{15}
....	188	....	....	....	....	....	188	....	....	188^{2}
....	....	....	....	....	....	189^{2}	....	189	....	189^{3}
....	....	....	....	....	....	190	....	....	....	190
....	191	....	....	....	....	.	....	191	....	191^{2}
....	.	....	....	....	....	192^{2}	....	....	....	192^{2}
....	....	....	....	....	....	....	....	193	....	193
....	....	....	....	....	....	194	....	....	....	194
....	....	....	....	197	....	197	....	....	....	197^{2}
....	....	....	....	199	....	199^{2}	....	....	....	199^{3}
....	....	....	....	....	....	200	....	200	....	202^{2}
203	....	....	....	....	....	....	....	....	....	203
....	....	....	....	204	....	204	....	....	....	204^{2}
....	....	....	....	....	....	208	....	....	....	208
....	....	....	....	....	....	215	....	....	....	215
....	223	....	....	....	....	....	....	....	....	223
....	227^{4}	....	....	227	....	227^{2}	....	....	....	227^{7}
....	228^{3}	....	....	228	....	228^{15}	....	228	....	228^{20}
....	229^{10}	....	....	229^{2}	229	229^{27}	....	229	229	229^{42}
....	230	230^{4}	230^{4}	....	230^{6}	230^{11}	....	....	230	230^{27}
....	....	....	231	....	....	231^{3}	....	....	....	231^{4}
....	232^{3}	....	....	....	....	232	....	....	....	232^{4}
....	233	....	....	....	233^{12}	233^{2}	....	....	....	233^{15}
....	....	234^{4}	234^{4}	234	234^{2}	234^{10}	234^{2}	....	....	235^{21}
....	....	235^{3}	235^{3}	....	235^{3}	235^{7}	....	....	....	235^{16}
....	....	....	....	....	236^{3}	....	....	....	....	236^{3}
....	....		....	....	....	..	237	....	....	237
....	....	....	238		....	238	....	....	....	238^{3}
....	....	....	....	239^{2}	....	239^{10}	....	....	....	239^{12}
....	240	....	240^{2}	....	240	240^{4}	240	....	....	240^{9}
242^{2}	242	....	....	....	....	....	.	....	....	242^{3}
....	243^{2}	....	243^{4}	243^{10}	....	243^{3}	243	243	....	243^{21}
....	244	....	....	244	....	244^{3}	244	....	....	244^{6}
....	....	....	....	....	....	245	....	....	....	245
....	....	....	....	....	....	246	....	....	246	246^{2}
....	....	....	....	....	....	....	....	....	247	247
248^{2}	248^{12}	248^{7}	248^{7}	248^{15}	....	248^{23}	248	248	248	248^{69}
249	249^{12}	249^{7}	249^{6}	....	249^{3}	249^{21}	249	....	....	249^{51}

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, N. S., 1903.—*Continued.*

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.	Province of Nova Scotia. YEAR 1903.
	250^{2}		250^{4}			250^{14}		250		250^{21}
251	251^{2}		251^{4}	251^{2}	251^{2}	251^{15}	251			251^{17}
			252			252^{3}				252^{4}
						254				254
							256			256
259						259			259	259^{3}
						260				260
						261				261
									263	263
266										266
267			267							267^{2}
270										270
						271^{6}			271	271^{7}
						272			272	272^{2}
						273				273
				278						278
				279						279
				280						280
						281				281
	282									282
285^{3}	285^{4}			285^{2}						285^{9}
289	289									289^{2}
290^{7}	290^{8}	290^{5}	290			290^{4}				290^{25}
291^{5}	291^{2}				291^{2}	291^{5}				291^{14}
	299		299^{2}	299^{4}						299^{7}
						304				304
				306						306
310	310^{2}									310^{3}
			311^{2}	311^{9}		311^{8}	311	311	311	311^{22}
				312		312^{4}	312^{2}	312	312	312^{9}
						318				318
						321	321^{2}			321^{3}
				322^{4}		322^{9}	322	322	322	322^{16}
						323				323
						324				324
						328				328
						341^{2}				341^{2}
									360	360

Thunderstorms—Phenological Observations, Nova Scotia, 1904.

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

Observation Stations

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv., & Victoria).	10. Inverness Slope to Gulf.	Province of Nova Scotia. Year 1904.
									4	4
				32		32				32^{2}
38										38
						54				54
						56				56
				60		60				60^{2}
	61^{2}									61^{2}
	62^{48}		62^{3}	62^{18}		62^{4}				62^{73}
63^{16}	63^{10}	63^{10}	63^{19}	63^{6}	63^{19}	63^{58}	63^{2}		63	63^{141}
64			64	64		64^{6}	64	64		64^{11}
						66				66
			67							67
			68^{3}							68^{3}
	70									70
71				71		71				71^{3}
				72						72
73										73
				74						74
77						77				77^{2}
					81		81			81^{2}
83^{6}	82^{19}			82						82^{20}
	83			83^{6}						83^{13}
						88^{2}				88^{2}
						91				91
					92					92
		93^{9}								93^{9}
						94				94
								95		95
97^{2}										97^{2}
	101^{17}	101^{4}	101			101^{2}		101	101	101^{26}
102^{2}	102^{6}	102^{15}	102		102^{13}	102^{27}				102^{64}
103^{14}	103			103		103^{2}		103	103	103^{20}
104										104
						109	109^{6}	109		109^{8}
					110^{2}					110^{2}
	111									111
						112				112
			114							114

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, N. S., 1904.—*Continued.*

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Pictou & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.	Province of Nova Scotia. YEAR 1904.
......	......	....	......	.....	.....	......	.....	......	117	117
......	......	......	......	....	......	119	......	....	......	119
......	......	.....	120	120	......	120^{9}	120	120^{3}	120^{3}	120^{18}
......	.	121^{7}	121^{12}	....	121^{12}	121^{48}	.....	......	.....	121^{79}
......	.....	.....	.....	122	...	122^{3}	......	.....	.....	122^{4}
....	.....	...	......	.....	......	123	.....	......	.....	123
.....	.....	......	.....	...	124	124^{12}	....	.....	....	124^{13}
.....	....	....	....	......	....	125	....	......	......	125
....	.....	.....	126	...	...	126	.....	......	......	126^{2}
...	....	...	......	.....	.....	128^{2}	.....	128	......	128^{3}
....	...	.....	...	....	.....	....	.....	.....	129	129
....	.....	....	.....	130	.....	130	.....	......	......	130^{2}
.....	...	.....	137	...	.....	137^{2}	137	......	.....	137^{4}
.....	.....	....	138	138	......	.....	.....	......	......	138^{2}
.....	....	...	....	.....	.....	140	...	.....	....	140
..	......	....	141	.....	.....	141^{15}	.....	......	.....	141^{16}
.....	......	....	.....	....	......	.....	.....	144^{3}	144^{4}	144^{7}
145^{6}	145^{3}	.....	145^{4}	145	.....	145	.....	.....	145	145^{16}
146	146	....	..	146^{7}	....	146	146	.....	.....	146^{11}
......	147^{2}	147^{2}	.....	147^{7}	......	147^{4}	147^{8}	147^{3}	.....	147^{26}
...	148^{5}	.....	....	....	148^{2}	148^{5}	148^{12}	......	148^{5}	148^{29}
......	....	.....	.....	......	...	....	149^{3}	149	.....	149^{4}
......	150	......	....	.....	.....	.....	.....	.....	......	150
...	.....	....	......	......	.....	151^{2}	.....	151	151	151^{4}
...	.....	.....	.....	154	154	.....	.....	.....	.....	154^{2}
.....	.....	....	155	....	.....	155	155^{2}	......	.....	155^{4}
156	156	...	156	.....	....	.....	.....	.....	.....	156^{3}
157	157^{4}	......	.....	......	....	......	157	....	......	157^{6}
158	....	.....	.....	......	......	158	....	......	.....	158^{2}
161	.....	..	.....	.....	......	......	......	.....	......	161
.....	.....	.....	.....	.....	.....	162	....	.....	.....	162
.....	.....	......	.....	163	......	163^{2}	....	.....	......	163^{3}
...	.....	.....	....	.....	164	......	.....	......	.....	164
.....	......	.....	165	....	......	......	.....	.....	165^{2}	165^{3}
......	166	....	.....	......	......	......	......	......	.....	166
......	167^{3}	....	167^{2}	167^{4}	....	167	.....	....	167	167^{11}
168	168^{3}	.....	168^{9}	168^{4}	168^{4}	168^{39}	......	168	168	168^{62}
169	169	169^{8}	169^{2}	....	.....	169	....	......	169	169^{14}

THUNDERSTORMS—PHENOLOGICAL OBSERVATIONS, N. S., 1904.—*Continued.*

The indices indicate the number of stations from which the Thunderstorms were reported on the day of the year specified.

OBSERVATION STATIONS.

1. Yarmouth and Digby.	2. Shelburne, Queens and Lunenburg.	3. Annapolis and Kings.	4. Hants and South Colchester.	5. Halifax and Guysboro.	6. S. Cobequid Slope (S. Cum. & Col.)	7. North Cum., Col., Picton & Antig.	8. Richmond and Cape Breton.	9. Bras d'Or Slope (Inv. & Victoria).	10. Inverness Slope to Gulf.	Province of Nova Scotia. YEAR. 1904.
170	....	170^{5}	170^{12}	....	170^{9}	170^{30}	170^{2}	170	170^{4}	170^{64}
171	......	.....	171^{2}	.....	......	171^{4}	.....	....	....	171^{7}
......	172	......	......	.....	172	172^{8}	.....	....	......	172^{10}
173^{5}	173^{11}	.....	173^{12}	173^{5}	173^{9}	173^{22}	.....	173	.....	173^{65}
174^{3}	174	174^{6}	174^{7}	174^{2}	174^{2}	174^{13}	.....	174	....	174^{35}
175	175^{9}	......	......	......	......	175^{4}	......	....	.....	175^{14}
176^{6}	176^{4}	......	176	176	.....	....	.....	....	.....	176^{12}
177^{2}	177	.....	177^{3}	.....	177	177^{3}	.....	.....	.....	177^{10}
......	......	......	178	178	178^{2}	.....	.....	......	......	178^{4}
179	......	......	.....	.....	.....	.....	......	......	.....	179
181	......	.....	181	.....	......	.....	.....	......	......	181^{2}
.....	......	......	182	......	......	......	......	....	......	182

PHENOLOGICAL OBSERVATIONS, CANADA, 1904.

"WHEN FIRST SEEN."

OBSERVATION STATIONS.

Number.	Day of the year corresponding to the last day of each month. Jan ...... 31 July .... 212 Feb. .... 59 Aug...... 242 March .. 90 Sept .....273 April ....120 Oct.......304 May .... .151 Nov .....334 June ... .181 Dec. ... 365 For leap year add one to each except January.	Average dates for Nova Scotia	*St. John, N B.	Charlottetown, P. E. I.	Kensington, P. E. I.	Ottawa, Ont.	†Creemore, Ont.	Guelph, Ont.	Shellbrook, Sask.	Vancouver, B. C.
*1	Alnus incana, Wild	106 9	118	120	....	114	....	117	....	75a
2	Populus tremuloides	118.	125	132	....	118	126	123	....	....
3	Epigæa repens, L............	109.1	125	120	116	118	....	....	....	....
4	Equisetum arvense	128.8	....	....	131	†124	....	127	....	102
5	Sanguinaria Canadensis	127.5	....	...	....	124	.. .	117	....	....
6	Viola blanda	126.3	131	....	127	†127	142	129	....	. ..
7	Viola palmata, *cucullata*, etc.	130.	130	....	134	130	134	132	...	....
8	Hepatica triloba, etc	122.3	125	....	....	107	126	123	....	....
9	Acer rubrum....	128.8	125	132	136	....	....	125	....	100b
*10	Fragaria Virginiana.	127 7	131	146	136	127	....	132	....	...
11	" " (fruit ripe).	161.9	162	....	....	...	..	....	....	....
12	Taraxacum officinale	131.6	139	135	139	127	130	112	...	....
13	Erythronium Americanum....	137.7	125	....	....	122	126	117	....	....
14	Coptis trifolia	133.2	....	...	137	†133	....	144	...	....
15	Claytonia Caroliniana........	128.1	...	....	....	115	...	117	....	....
16	Nepeta Glechoma............	138.4	....	....	...	†133	....	....	...	108
17	Amelanchier Canadensis.... .	137.1	139	....	139	133	....	132	. ..	....
18	" " (fruit ripe)	200.1	....	....	....	....	....	....	....	....
19	Prunus Pennsylvanica	144.5	149	....	139	122	142	....	....	114c
20	" " (fruit ripe)	215.9	....	....	....	....	....	....	....	....
21	Vaccinium Can. and Penn. ..	141.7	146	....	148	135	..	135	....	80
22	" " (fruit ripe)	207.6	....	....	....	....	....	...	...	....
23	Ranunculus acris	147.5	...	...	156	....	...	151	....	134
24	R. repens	156.9	...	...	170	.. .	....	....	....	128
25	Trillium erythrocarpum.....	145.9	139	. .	141	127	....	....	....	....
26	Rhododendron Rhodora	145.1	139	....	151	....	....	....	...	...
27	Cornus Canadensis.....	147 2	....	....	147	152	....	163	....	133
28	" " (fruit ripe)	212.6	..	....	....	....	....	....	....	....
29	Trientalis Americana	148.5	146	....	159	138	....	..	148	....
30	Clintonia borealis	151.5	149	...	160	138	....	148	....	....
31	Calla palustris.	158.5	....	....	131	....	....	163	....	....
32	Cypripedium acaule..........	157.1	162	....	162	....	....	156	..	....
33	Sisyrinchium angustifolium ..	158.	....	....	172	145	..	..	....	....
34	Linnæa borealis	162.9	....	....	168	...	...	163	....	....
35	Kalmia glauca	151.1	....	....	....	....	....	143	....	....
36	Kalmia angustifolia...... .	170.1	....	....	172	...	....	..	....	....

a. Alnus rubrum ; b. Acer macrophyllum ; c. Prunus emarginata.

*When becoming common, except 1 and 11.

†When becoming common.

PHENOLOGICAL OBSERVATIONS, CANADA, 1904.

"When First Seen."

Observation Stations.

Number.	Day of the year corresponding to the last day of each month. Jan .... 31 July ....212 Feb ..... 59 Aug......242 March. .. 90 Sept .... 273 April . ..120 Oct... .. 304 May......151 Nov... ..334 June .....181 Dec......365 For leap year add one to each except January.	Average dates for Nova Scotia.	*St. John, N. B.	Charlottetown, P. E. I.	Kensington, P. E. I.	Ottawa, Ont.	†Creemore, Ont.	Guelph, Ont.	Shellbrooke, Sask.	Vancouver, B. C.
37	Cratægus Oxyacantha	162.	149	....	....	142	....	....	....	....
38	Cratægus coccinea, etc	157.7	....	161	....	....	....	148	....	....
39	Iris versicolor....	164.6	162	....	175	....	....	188	....	....
40	Chrysanthemum Leucan......	164.8	....	....	167	....	....	169	....	....
41	Nuphar advena..............	164.9	....	....	....	151	....	162	....	....
42	Rubus strigosus	160.6	....	....	170	151	....	155	....	74d
43	" " (fruit ripe)....	217.5	....	....	....	....	....	....	....	152
44	Rhinanthus Crista-galli	172.7	....	....	....	....	....	....	....	....
45	Rubus villosus	166.	....	....	....	....	....	160	....	....
46	" " (fruit ripe) ...	239.7	....	....	....	....	....	....	....	....
47	Sarracenia purpurea	168.1	....	....	....	....	....	158	....	....
48	Brunella vulgaris............	173.3	....	....	179	....	....	178	....	....
49	Rosa lucida	179.9	....	....	....	....	....	197	....	....
50	Leontodon autumnale.......	167.6	....	....	161	....	....	....	....	....
51	Linaria vulgaris	176.	....	....	....	....	....	....	....	....
52	Trees appear green	136.8	....	....	....	127b	146	....	....	100
53	Ribes rubrum (cultivated)....	141.8	....	....	....	....	....	....	....	....
54	" " (fruit ripe) .. .	203.4	....	....	....	....	....	....	....	....
55	R. nigrum (cultivated)	142.9	....	....	148	....	....	....	....	....
56	" (fruit ripe)........	209.4	....	....	....	....	....	....	....	....
57	Prunus Cerasus............ ..	147.4	....	149	150	....	....	....	....	104
58	" " (fruit ripe)	210.	....	....	....	....	....	....	....	....
59	Prunus domestica	151.1	....	....	146	129	....	....	....	103
60	Pyrus malus	150.5	....	149	146	....	....	....	....	112
61	Syringa vulgaris.............	157.6	....	161	158	....	....	....	....	125
62	Trifolium repens.............	157.3	....	....	158	....	....	....	....	127
63	Trifolium pratense...........	155.7	....	....	159	†128	....	....	....	140
64	Phleum pratense	157.2	....	....	....	....	....	....	....	....
65	Solanum tuberosum..........	176.8	....	....	....	....	188	....	....	....
66	Ploughing (first of season)....	119.3	....	....	124	....	....	....	....	....
67	Sowing " .. .	128.4	....	....	127	....	....	....	....	....
68	Potato-planting "	126.6	....	....	....	....	145	....	131	....
69	Sheep-shearing " ...	129.6	....	....	....	....	144	....	....	....
70	Hay-cutting "	205.7	....	....	....	....	194	....	196	....
71	Grain-cutting " ...	248.3	....	....	....	....	202	....	....	....
72	Potato-digging " ..	266.2	....	....	276	....	....	....	....	....

d. Rubus spectabilis.
*When becoming common.
†When becoming common.

PHENOLOGICAL OBSERVATIONS, CANADA, 1904

"WHEN FIRST SEEN."

OBSERVATION STATIONS.

Number.	Day of the year corresponding to the last day of each month Jan ...... 31 July......212 Feb ..... 59 Aug......242 March.. . 90 Sept... .273 April.. ..120 Oct ..... 304 May......151 Nov. .. 334 June... ..181 Dec... ..365 For leap year add one to each except January.	Average dates for Nova Scotia.	St. John, N. B.	Charlottetown, P. E. I.	Kensington, P. E. I.	Ottawa, Ont.	Creemore, Ont.	Guelph, Ont	Shellbrooke, Sask.	Vancouver, B C.
73a	Opening of rivers (1st of season)	88.5	....	103	....	....	....	....	.	....
73b	Opening of lakes "	107.1	..	....	....	....	....	...	...	....
74a	Last snow to whiten ground .	112.2	....	....	...	....	....	....	..	82
74b	" to fly in air	118.4	..	....	117	....	....	....	...	82
75a	Last spring frost—hard	138.9	....	....	97	....	...	...	...	....
75b	" " hoar	159 8	163	126	124	....	....	...	.	....
76a	Water in streams—high. . .	102.5	...	...	...	....	107	..	.	....
76b	" " low	186 8	....	..	...	....	....	....	.	....
77a	First autumn frost - hoar	271.9	....	252	252	....	227	....	..	....
77b	" " hard	296 3	281	....	280	....	. ..	....	.	....
78a	First snow to fly in air	299.6	....	262	301	..	....	...	. .	....
78b	" whiten ground .	308.3	. ..	..	306	...	....	..	..	....
79a	Closing of Lakes	342.5	....	...	....	....	..	....	. .	. . .
79b	" Rivers	340.9	. .	344	....	....	...	...	.	....
81a	Wild ducks migrating, N ..	88.3	....	....	....	....	124	123	..	. .
81b	" " S ...	295.7	...	....	....	....	....	..	...	. .
82a	Wild geese " N	83.9	....	69	....	....	....	...	94	....
82b	" " S	312 5	....	260	....	....	....	.	..	....
83	Melospiza fasciata, North ...	91.2	..	88	92	85	86	83	...	....
84	Turdus migratorius, "	88 1	....	90	92	84	85	83	111	....
85	Junco hiemalis, "	87.3	...	90	92	93	....	Res	.	....
86	Actitis macularia, "	127.4	...	....	...	....	....	120	..	....
87	Sturnella magna, " ...	121.7	...	....	....	93	.. .	83	112	. .
88	Ceryle Alcyon, "	124.9	...	....	....	114	...	97	.	....
89	Dendrœca coronata, "	134.5	....	....	...	....	....	120	. .	....
90	D. æstiva, " . .	134.6	....	....	....	128	....	126	. .	...
91	Zonotrichia alba, " ..	119 4	...	....	....	....	....	146	..	....
92	Trochilus colubris, " ...	145.6	....	....	....	....	....	141	..	. .
93	Tyrannus Carolinensis" ...	140.1	....	....	....	....	...	126	...	....
94	Dolychonyxoryzivorus"	133.8	....	....	....	....	....	124	...	....
95	Spinis tristis, " .. .	143.7	....	....	....	...	151	Res.	...	....
96	Setophaga ruticilla. "	137.3	....	....	....	128	....	140	..	....
97	Ampelis cedrorum. " ...	142.	....	....	...	....	....	147	.	....
98	Chordeiles Virginianus ' . ..	122.5	...	149	....	....	....	155	.	....
99	First piping of frogs	108.7	....	114	123	108	112	...	113	....
100	First appearance of snakes. ..	116.2	....	....	168	....	93	....	111	....

80 No Thunderstorms:
Charlottetown, P. E. I.:—63, 121, 141, 148, 202, 210, 231, 262.
Kensington, P. E. I.:—63, 121, 148, 170, 182, 202, 230, 242, 262.
Creemore, Ontario:—129, 191, 202, 246, 255, 273.

Edible Wild Plants of Nova Scotia.—By Walter H. Prest, Bedford, N. S.

(Read 13th March, 1905.)

These notes on the edible wild plants of Nova Scotia are the result of my early experience in the backwoods, and are offered with the hope that they may prove of benefit to those whom business or accident may lead temporarily beyond the reach of the resources of civilization. While some of the wild fruits here mentioned, such as the blueberry and cranberry, are of commercial value, others are included because they may assist in sustaining life at a critical time. While lost in the forest, persons have perished through a want of knowledge of the resources which nature has bounteously provided in many sections at certain seasons of the year. As these resources are more animal than vegetable, the latter class has been much neglected. Therefore, the result to a lost man, unprovided with weapons or the means of snaring, trapping or catching game or fish, might be perhaps serious. I propose, therefore, to tabulate these edible plants, so far as known to me, and describe as freely and popularly as possible, all that have come under my personal notice. To Dr. A. H. MacKay I am indebted for several of the more difficult scientific identifications. As, however, the best scientific description, especially during the fruiting season, would be almost useless to the average man, we will be forced to largely fall back on nature's testing apparatus, the eyes, nose and mouth.

The nuts and seeds, with few exceptions, do not repay the labor and time spent in gathering, except in extreme cases; therefore an astute backwoodsman searches the hillsides for the stores of food buried by ground squirrels for winter use. These

industrious little animals dig burrows usually in the side of a small knoll (or cradle-hill as it is often called). The entrance is about 1 in. wide, and descends about 1 ft. at an angle of 40° to 50°, though often nearly vertically. After a tortuous and somewhat horizontal course of 2 ft. to 5 ft., a chamber nearly 1 ft. in diameter is made. In this is the nest, packed round with nuts and seeds of various kinds. Several branch burrows also contain the same kind of food, often to the amount of three or four gallons.

A knowledge of the appearance, location, and edible qualities of the plants described herein, though not always ensuring a bounteous meal, will, without doubt, keep off the pangs of hunger so frequently dwelt on in tales headed "Lost in the woods." To a backwoodsman of ordinary intelligence such stories sound like gross exaggerations. A pocket knife, a tin kettle, and a few matches, provide means of existing in a forest which would be totally inadequate in a city. The addition of a little sugar and salt would place him beyond need, and if he has any skill as a trapper the animal world would also be largely at his mercy.

Note.—The descriptions in this paper are intended to be given, as far as possible, in plain, untechnical language, so as to be easily understood by those for whom the paper is primarily intended, namely, persons with little or no botanical knowledge. The writer does not wish to be considered as at all attempting to present technically accurate descriptions, which may be found in various systematic works. The nomenclature is mainly that of Gray's *Manual of Botany.*

FRUITS AND BERRIES.

1. Vaccinium Canadense Kalm., and *Vaccinium Pennsylvanicum* Lam. Canadian, and Dwarf Blueberry.

Two species much alike; but the former has downy leaves with entire edges, the latter little or no down and finely-toothed

edges. 5 in. to 24 in. high, many branched, brownish-grey main stalks with green leaf stalks. Leaves, oblong and pointed, $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. long, $\frac{1}{4}$ in. to $\frac{1}{2}$ in. wide, thin, light green. Berries blue to blueish-black, with thin skin, purple juicy pulp and many small seeds. Sweet to slightly acid, globular, $\frac{3}{10}$ in. to $\frac{4}{10}$ in. thick. A wholesome and valuable article of food. Eaten raw or easily prepared. Sometimes the delicious sweetish fruit is in heavy clusters.

Grows on open barrens and dry partly wooded land, sometimes covering large districts with its abundant growth. Forms a large item in the exports of Yarmouth county. Ripens in July and August.

2. *Vaccinium uliginosum* L. Great Bilberry.

Bush 4 in. to 10 in. high. Branches spreading and tufted, but not so thickly branched as blueberry. Leaves oblong, narrowed at the base, $\frac{1}{2}$ in. to 1 in. long, pale beneath. Berries purple to black, juicy pulp with small seeds, sweetish taste, slightly oblong and pear-shaped with thick end next stalk, $\frac{4}{10}$ in. long. Pleasant and wholesome food. Does not grow in clusters as do blueberries.

Found on barrens with blueberries, very rarely in swampy land. Not plentiful. Grows chiefly in the western and northern counties. Too rare to be considered an important article of food in this country.

3. *Vaccinium macrocarpon* Aiton. Large Cranberry.

A creeping vine, 6 in. to 30 in. long, from which the fruitstalk ascends 3 in. to 6 in. Leaves oblong, $\frac{3}{10}$ in. to $\frac{5}{10}$ in. long, evergreen, dark-brownish green above and pale beneath, with turned-back edges, thick and somewhat ridged, attached directly or almost so to the vine, two bracts on fruit stalk. Berries, 1 to 3 on each fruit stalk, red when ripe, round to slightly oblong, $\frac{1}{2}$ in. to $\frac{3}{4}$ in. long, ripens late and remains in

good condition until next May. Very acid, but one of the most digestible of our sour berries.

Easily domesticated in fields or prepared bogs. Sometimes very abundant in meadows and along stillwater brooks; but often found in dry fields and on sandy hills and flats. Generally distributed in Nova Scotia.

4. Vaccinium Oxycoccus L. Small Cranberry, "Bog-berry."

A creeping vine, 4 in. to 10 in. long, very slender, with thread-like fruit stalks, Leaves ovate or egg-shaped, few and irregularly disposed, $\frac{2}{10}$ in. long, with curved margins. Berries round, $\frac{3}{10}$ in. thick, with a few small seeds, generally one berry on each fruit stalk, which seldom stands erect, very sour, changes from white with greyish-brown spots to red when ripe, ripens late like the large cranberry, but remains good until the next May. Very palatable, but requires much sugar.

Found on moderately wet open bogs, only on a certain green or reddish-green moss, but never on dry soil or water-covered meadows, as the large cranberry. Either too much or too little moisture is fatal to its growth. Generally distributed, but rarely very plentiful.

5. Vaccinium Vitis-Idæa L. Foxberry, Mountain Cranberry, "Cowberry," locally "Partridge-berry."

Vine 6 in. to 10 in. long, tufted creeping stems, with erect ends 1 in. to 3 in. high. Leaves alternate and closely set on stems $\frac{1}{3}$ in. long, wide oval, not pointed, slightly notched at ends, dark green, thick and hard with turned-back edges, smooth and shining above, light green, smooth, with very small black spots below. Berries round, $\frac{1}{3}'$ thick, dark red, acid and very slightly bitter, mealy, juicy after becoming ripe, seeds few and small. Berries in bunches of from 2 to 5, very productive. Important as an article of food, but requiring much sugar.

On bare headlands, barrens or other exposed situations, usually near or on the sea coast, seldom found on wet soil or

far inland. Widely distributed and plentiful in the eastern and northern counties, scarcer in the western counties. Ripe in September; remains late, but does not keep as well as the large cranberry.

6. *Gaylussacia resinosa* T. & G. Huckleberry.

Bush 1 ft. to 10 ft. high, many branched, thin limbed. Leaves oblong, $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. long, light green above and below, thinner and larger than blueberry leaves, often spotted with red. Berries round, black, $\frac{3}{10}$ in. to $\frac{4}{10}$ in. thick, more seedy than the blueberry, but more juicy, sweeter, and better flavored, one of the most palatable and agreeable of Nova Scotian wild fruits. Bushes well laden, but fruit distributed more evenly and on longer fruit stalks than the blueberry.

Associated on barrens and partly wooded land with blueberry, but unlike the latter often capable of growing in more shady places. A valuable food, but will not keep long. Widely distributed and plentiful everywhere throughout Nova Scotia. Ripens in August, after the blueberry.

7. *Viburnum lantanoides* Mx. Hobble-bush, locally "Moose-bush."

A shrub 6 ft. to 9 ft. high, with spreading branches, growing in pairs from main stalk and larger branches, the pairs alternating at right angles to each other. Bark, brown to brownish-grey on all branches except the growths of the present year, which are covered with a light green velvety bark, continuous to the ends of the leaf ribs. The old bark is spotted with minute white warts. Leaves in pairs opposite each other on leaf stalks, 2 in. long, 3 in. to 6 in. diameter, round, but curved inward at junction with leaf stalk, thick, soft, smooth above, scurfy to downy beneath, somewhat wrinkled, leaf-ribs large, leaves toothed irregularly and slightly pointed. Berries in widely spreading flat topped bunches, 3 in. to 5 in. across, no berries on outer row of flower stalks. Changing from red to

black when ripe, $\frac{3}{10}$ in. to $\frac{4}{10}$ in. thick, somewhat flat, and containing a single hard flat seed about half the size of the fruit, thin skinned, with moist soft black pulp, very sweet and easily digested, decays soon, unless eaten by birds and squirrels. Ripens in August.

Grows in deep shady woods, in moderately dry soil. Widely distributed, but not very abundant.

8. *Viburnum Opulus* L. Cranberry-tree, Bush Cranberry.

Shrub 5 ft. to 12 ft. high, with many branches. Bark light grey. Leaves 3 to 5 ribbed, strongly lobed, lobes pointed, base of leaf wide, sides notched. Berries $\frac{3}{10}$ in. long, round, bright red, very sour but pleasant, with a single thin flat smooth seed. Smooth skinned, juicy, remains uninjured until spring.

In low or moist rocky lands, or beside streams, but not in swamps, meadows or pine timber land. Preserve made of the berries is sometimes to be had in the Halifax country market. Plentiful only in a few districts of the northern and western counties.

9. *Viburnum cassinoides* L. Withe-rod.

Bush 5 ft. to 8 ft. high, thin, tough, wiry, branches few, which ascend at slight angle with main stem ; much used for basket making. Bark light brown. Leaves 2 in. to 3 in. long, oval, pointed, wavy margin notched into rounded teeth, dark green, not shining nor very thin. Berries slightly flattened, $\frac{2}{10}$ in. to $\frac{3}{10}$ in. long, with a bluish bloom, smooth black skin and pulp, with a flattened stone, sweet, but pleasant tasting, agreeable and easily digested, and of considerable value as an article of food. Their dark color makes them objectionable to some whose fastidiousness exceeds their common sense.

In nearly all meadows, swamps, wet barrens and low open lands, often in great abundance. Widely distributed.

10. Cornus Canadensis L. Dwarf Cornel, Bunch-berry, locally "Pigeon-berry."

Slender green red-ribbed stalk $2\frac{1}{2}$ in. to $4\frac{1}{2}$ in. high, rising from long tangled creeping roots, evergreen. Four large white petal-like bracts surround the cluster or bunch of small inconspicuous flowers. Leaves 4 to 6, ovate, pointed at both ends, $1\frac{1}{4}$ in. to 2 in. long, arranged in a whorl at foot of fruit stalk, light green, smooth, grooved above and ribbed below, two scale like leaves clasp the stem lower down. Leaf stalk very short. Berries in a bunch, round, red, $\frac{2}{10}$ in. to $\frac{3}{10}$ in. thick, smooth skinned, fleshy white or pinkish pulp of sweetish taste, containing a single large, hard, round, white seed, which is hard to separate. Its value as a food is therefore slight in spite of its abundance. The seed, however, is easily crushed between the teeth.

Grows in mixed woods in moderately dry soil where ground is not too thickly covered by leaves. Ripens in August and September. Very plentiful and widely distributed.

11. Chiogenes hispidula T. & G. Creeping Snowberry, locally "Maidenhair," "Capillaire."

Slender creeping vines, often grows in thick and matted masses. Leaves evergreen, oval, $\frac{3}{10}$ in. long, not notched, margins curved, light green, smooth above, bristly below, leaf stalks extremely short, has the aromatic taste of the birch or tea berry. Berry white, $\frac{3}{10}$ in. long, slightly oblong, with many minute seeds, dry and mellow with a sweetish spicy flavor, without visible fruit stalks. Nova Scotia's most delicious berry; either eaten uncooked or as a preserve. Ripens in July and August.

Grows in mossy woods or shady bogs where not too wet. Generally distributed and fairly abundant, though their small size makes them unimportant as an article of food. Make very delicious preserve.

12. *Gaultheria procumbens* L. Creeping Wintergreen, Checkerberry, locally "Tea-berry," "Deer-berry," "Partridge-berry."

Stalks 2 in. to 4 in. high, connected beneath the surface. Leaves in a crown of 2 to 4, smooth and dark green, ovate, slightly pointed and minutely notched, $\frac{3}{4}$ in. to $1\frac{1}{4}$ in. long, edges curved, hard, thick, light green below, strongly aromatic odor and taste, containing a volatile oil known as wintergreen, used as a flavor or perfume. Flowers small pinkish-white and cup-shaped, in bunch of 2 to 3 beneath leaves, which are nearly edible. The juice of the chewed leaves is very invigorating. Berries bright red, round, end indented and containing dark-colored bristle in centre, $\frac{3}{10}$ in. to $\frac{4}{10}$ in. thick, pulp dry and spicy. Does not complete its growth in one season, remains on stalk over winter, and increases in size and ripeness next spring.

Dry barrens, open or burnt woods, and old pastures. Widely distributed and abundant, available at all times except July to September.

13. *Prunus Pennsylvanica* L. Wild Red Cherry, Bird Cherry.

Small tree 7 ft. to 20 ft. high, with many straight thin branches. Bark smooth, light reddish-brown; outside thin and paper-like, but tearing easily in strips around the trunk, inside green and intensely bitter. Leaves very oblong and sharply pointed, notched, thin, shining light green and smooth on both sides, on leaf stalks 1 in. long. Berries not in a long cluster, round, $\frac{2}{10}$ in. to $\frac{8}{10}$ in. thick, smooth skinned, red, juicy, very sour, somewhat clustered, but on fruit stalks 1 in. to $1\frac{1}{2}$ in. long; contains a single round hard seed with bitter kernel, which is more or less unsafe to eat. Ripens in July.

On the driest and rockiest soil, on barrens and burnt or open woods, never in swamps. Widely distributed, and often extremely plentiful. Much eaten by birds.

14. Prunus serotina Ehrh. Wild Black Cherry.

A large tree, 15 ft. to 50 ft. high, often used for cabinet work. Bark rough and dark grey on trunk, with reddish-brown branches, thin outside bark, and very bitter inner bark. Leaves very oblong, tapering to a point, a little larger and thicker than the leaves of the wild red cherry, dark green and shining above, a little lighter and duller below, on leaf stalks nearly 2 in. long. Berries in a long cluster, round, $\frac{4}{10}$ in. thick, purplish black, pulpy, juicy, sour to slightly bitter but pleasant and digestible, contains a single slightly oval hard seed. Ripens in August.

Found chiefly on rich intervales, Musquodoboit, Shubenacadie, and other valleys. Not very plentiful, though widely distributed.

15. Prunus Virginiana L. Choke-cherry.

A shrub 5 ft. to 10 ft. high, consisting chiefly of separate stems from the same root. Leaves oblong, abruptly pointed, 3 in. to 4 in. long, dark green, sharply notched. Bark rough, greyish-brown. Berries in a long cluster, crimson-brown or nearly black, round, $\frac{3}{10}$ in. to $\frac{4}{10}$ in. thick, moderately sour, juicy, astringent, pleasant, digestible, with single slightly oval hard seed; arranged thickly and regularly to the number of 10 to 16 on long fruit stalk. Ripens in August.

Grows around the edges of cultivated land, roads, intervales, seldom found in uninhabited districts. Widely distributed, and plentiful in the western counties; scarce in the east except in the older settlements and towns.

16. Pyrus arbutifolia L. Choke-berry.

A bush $1\frac{1}{2}$ in. to 7 in. high, branching tough stalk. Bark brownish-grey. Leaves oblong, pointed, finely notched, thick, dark green to brownish-green, smooth above and slightly downy beneath. Berries deep reddish-purple or nearly black, with

lighter colored juice, the stains of which are very difficult to efface, nearly round or slightly egg-shaped, $\frac{3}{10}$ in. to $\frac{4}{10}$ in. thick, smooth skinned, juicy, sweetish-sour, astringent; in heavy bunches, though each berry has a separate long fruit stalk. Pleasant and digestible. Contains several small seeds.

In meadows, wet intervales, or moist places in open woods and barren land. Widely distributed and abundant, especially in the southern counties.

17. Pyrus Americana D. C. American Mountain Ash.

Tree 8 ft. to 25 ft. high, straight and regularly branched. Bark greyish-brown. Leaflets $2\frac{1}{2}$ in. long, taper pointed, sharply notched, bright green above, pale green below, 13 leaflets on each leaf stalk. Berries in flat-topped clusters, round, size of field peas, bright red or scarlet, has a peculiar astringent sour taste unlike that of any other berry, therefore unpleasant to the great majority, pulpy, juicy, with few seeds. Grow in great flat clusters nearly on every branch, often covering the tree in a canopy of scarlet fruit. In autumn it is our most beautiful tree, much used as an ornament for lawns and gardens. Ripens in September, remaining uninjured long after the first frosts. Seldom used as a food.

In moist woods, hanging over river and lake banks, which it greatly beautifies. Particularly abundant in Yarmouth and Shelburne counties, becoming less plentiful going east.

18. Amelanchier Canadensis Medic. (2 or more varieties). Shad-bush, Service-berry, June-berry, June plum, locally "Indian Pear."

(a). Tree 6 ft. to 30 ft. high, branches ascending at a slight angle with the trunk, thin limbs and open foliage, close tough wood. Bark moderately smooth, light grey with dark grey or light brown stripes, running vertically. Leaves oblong, pointed, 2 in. to $2\frac{1}{2}$ in. long, sharply notched, heart-shaped at base in some

larger varieties, thin, dark or dingy green. Berries deep reddish-purple, round, on $\frac{1}{2}$ in. leaf stalk, size of large peas, 10-seeded, very sweet and pleasant tasting, containing more sugar than any other native fruit. These, with huckleberries and witherod berries, are the most easily digested and nourishing wild fruit of Nova Scotia.

In low woods and along banks of streams and lakes where alone it is abundant. Is scattered elsewhere. Generally distributed, but more plentiful in the western than the eastern counties.

(b). Small bush or twig, with 2 to 5 thin branches. Bark brownish-grey. Leaves oblong or oval with round end, notched, light green. Berries purple, oval, slightly longer than thick, $\frac{4}{10}$ in. to $\frac{5}{10}$ in. long, very sweet and juicy, superior to any other variety in taste and size, and well worthy of domestication, 10-seeded, scattered irregularly over bush, never in clusters.

On level and not too rocky barrens, and dry open lowlands, mixed with blue and huckle berries; seldom on river banks with the larger varieties. Generally distributed, but not very abundant; more plentiful in the western than in the eastern counties.

19. *Fragaria Virginiana* Duchesne. Wild Strawberry.

So well known that for practical purposes it needs no description. Pleasant and digestible, very abundant. Ripens in July.

Found almost everywhere in cultivated grounds, barrens and open woods, usually never far from settlements.

20. *Rubus strigosus* Mich. Wild Red Raspberry.

Very abundant and well known, description superfluous.

Around cultivated grounds, in pastures, open woods, and on barrens far from settlements. A juicy, delicious. and easily digested fruit. Ripens in August.

21. Rubus villosus Ait. Common or High Blackberry.

Well known accompaniment of cultivation, description unnecessary.

Found nearer settlements, but not so abundant as the raspberry. Generally distributed. Ripens in early part of September.

22. Rubus Canadensis L. Low Blackberry, Creeping Blackberry, Dewberry (?)

Thin trailing prickly vines. Leaf stalks with 3 leaflets, prickly, oval, pointed, sharply notched, thin and smaller than those of the high blackberry. Berries black, not in bunches, much smaller than those of the high blackberry, much like it in structure, taste, and juiciness; pleasant and easily digested.

Found chiefly in rocky, low, but not swampy ground, on flat barrens or in open woods, especially after the underbrush has been burned. Common in Nova Scotia, but not very abundant.

23. Rubus triflorus Rich. Dwarf Raspberry, locally "Dewberry," and "Mulberry."

Vine 3 in. to 6 in. high, reclining or upright, with 2 or 3 branchlets of 3 leaves each. Leaves oblong, pointed, doubly notched, thin, smooth, 1 in. to 1½ in. long. Berries ½ in. thick, red, with few and almost separate lobes, each containing a seed. Juicy, vinous, and pleasant.

Wet mossy woods or moderately wet bogs partly tree covered. Nowhere in great abundance though quite common.

24. Rubus Chamæmorus L. Cloud-berry, locally "Bake Apple."

Single stem 2 in. to 9 in. high, with 2 or 3 leaves on 1½ in. leaf stalks half way to top of stems. Leaves almost round, roughly 5-lobed, 1½ in. to 2 in. across, rough and slightly hairy. Berries 1 to 3, usually 1 on each plant on separate fruit stalks,

at first hard and light red, changing to a dark amber color when ripe, $\frac{1}{2}$ in. thick, consisting of a fewer, but larger, lobes than raspberry. Has a thick rich yellow juice, which leaves little residue, slightly acid, pleasant, wholesome and easily digested though somewhat seedy. Ripens early in August.

Found only on dry mossy bogs (savannas, so called) in the eastern part of Nova Scotia. More plentiful in northern Cape Breton. It reaches its greatest size and perfection in Labrador. Nova Scotia is near the southern limit of its growth, and it is rarer now than forty years ago.

25. *Ribes lacustre* Poir. Swamp Gooseberry.

Small bush 1 ft, to 2 ft. high, erect or slightly reclining, stem and branches full of sharp spines, bark light grey. Leaves 3-lobed, 1 in. across, light green, downy, leaf stalks short. Berries round. dark red when ripe, $\frac{3}{10}$ in. to $\frac{5}{10}$ in. thick, covered with small prickles, in bunches of 2 and 3 growing chiefly on sides of stem ; pulpy, juicy, moderately sour, with several large seeds. A pleasant food.

In open rocky or burned woods, old pastures or waste land. Common, but not very abundant.

26. *Ribes oxyacanthoides* L. Hawthorn Gooseberry, Northern Gooseberry.

Berries roundish, smooth, $\frac{1}{3}$ to $\frac{1}{2}$ inch in diameter, reddish purple when ripe. Low bush, spines solitary, light colored, $\frac{1}{4}$ to $\frac{1}{2}$ inch long, sometimes none. Prickles scattered or wanting. Leaves petioled, three to five lobed, nearly as broad as long, under surface and stalk generally bearing some down. Flowers, one to three on stalk less than $\frac{1}{4}$ inch, nearly $\frac{1}{4}$ inch long. Fruit more dainty and pleasant than the garden gooseberry when ripe.

27. *Ribes prostratum* L'Her. Fetid, Wild or Stinking Currant.

A reclining or creeping vine-like bush, ends of stems above being upright. Bark grey, when bruisod emits a peculiar and

intensely strong odor objectionable to some people at first, but not so disagreeable as elder. Leaves somewhat heart-shaped, but 5 to 7-lobed, 1 in. to 2 in. across, lobes pointed, doubly notched. Berries round, size of small field peas, red, slightly bristly, juicy, contains a few large seeds; in clusters of 8 to 20 on fruit stalks 2½ in. to 4 in. long; smell less strongly than bark or leaves, sour with a peculiar taste related to smell, but in spite of this is enjoyed by many people.

In rocky open woods or barrens. In greatest abundance where land is most rocky. Very abundant in southern and western counties of Nova Scotia and southern Cape Breton.

28. Ribes rubrum L. Wild Red Currant.

Stems straggling or reclining. Leaves somewhat heart-shaped, 3 to 5-lobed, notched. Berries round, a little larger than the stinking currant, smooth skinned, red, resembles the garden currant in size, taste, and foliage, without the strong smell of the former; makes a delicious preserve.

In open woods or waste land, in deep soil. Very scarce in Nova Scotia, found by me only in the northern counties.

29. Ribes floridum L'Her. Wild Black Currant.

Creeping stems, slightly spinous. Leaves much like those of the red currant. Berries round, black, same size as Ribes prostratum, bristly, with slightly musky smell and taste. Barely tolerable as a food.

In rocky open woods and moist barrens. Scarce in Nova Scotia.

30. Mitchella repens L. Partridge-berry, Snake-berry, sometimes locally "Wild Ivy-berry."

Slender evergreen vines, 4 in. to 12 in. long, scattered and creeping. Leaves round, $\frac{3}{10}$ in. long, scarcely pointed, arranged closely and regularly along vine, dark green and shining above,

light green below. Berries round or slightly flat at end, $\frac{3}{10}$ in. to $\frac{4}{10}$ in. thick, with 2 eyes or flower marks, the only common doubly marked berry we have, scarlet, almost tasteless or slightly sweet, nearly dry, fleshy, white pulp, remaining uninjured over winter and improving with time. Has 1 or 2 large seeds. Of little value as food.

In dry shady mossy woods where other plants are rare. Generally distributed, but not plentiful.

31. Sambucus Canadensis L. Common Canadian or Black-berried Elder.

Shrub 4 ft. to 9 ft. high, leaf stalks branching at almost right angles with stalk, woody, with large core of white pith. Bark, outside grey and paper-like, inside green and tender with a strong and disagreeable smell when bruised; often used for making a salve. Leaves 7 to 11 on each leaf stalk, 4 in. long, oblong, taper-pointed, notched, smooth. Berries round, $\frac{3}{20}$ in. thick, dark purple, our smallest berry, in thick, flat-topped bunches of 20 to 60; with purple juicy pulp, 3-seeded, peculiar acid taste. Liked by some people, disagreeable to others on account of taste. Probably nourishing if taste can be overcome.

In rich soil, open woods, burnt land, around old fields and brooks. Widely distributed, abundant in some places.

32. Sambucus pubens Mx. Red-berried Elder, "Boltry."

With large pyramidical clusters of red berries. Character very similar to those of the last mentioned.

33. Aralia nudicaulis L. Wild Sarsaparilla.

Stem 8 in. to 10 in. high, dividing at top into 3 leaf stalks, stems annual. Leaflets, 15 in number, viz., 5 on each leaf stalk, 2 in. to 4 in. long, oblong, taper-pointed, finely notched, altogether distinct from fruit stalks, though growing from the same long white far-reaching aromatic roots. Berries roughly round, dark brown to black, $\frac{1}{4}$ in. thick, with a few shart spines

around top of berry, watery, sweetish, not unpleasant, few seed; in large bunches or flat-topped clusters on tall fruit stalk. Food value slight.

Widely distributed and fairly abundant.

34. Aralia racemosa L. American Spikenard.

Herbaceous, much-branched, from 3 to 6 ft. high, in rich intervale soil. Leaves compounded of 3 or 5 leaflets, each roundish, heart-shaped at the base, pointed at the apex, 2 to 6 in. long, and sharply and finely toothed on the margins. Flowers in clusters, made up of numerous umbels, each floret small and greenish. The fruit, when ripe, consists of compound clusters of beautiful reddish-brown or purplish berries with a pleasant taste and peculiar aromatic flavor characteristic of the plant and its large rootstalk, which is used for flavoring home-made beer in some places. Not common.

35. Smilacina bifolia Ker. Two-leaved Solomon's Seal, locally "Cowslip."

Leaves and fruit on one stem, 3 in. to 5 in. high, roots creeping. Leaves, 2 in number, 2 in. long, 1 in. wide, heart-shaped, pointed, longitudinally ribbed, base almost clasping stem, somewhat downy. Berries red, round, $\frac{2}{10}$ in. thick, with 1 or two large seeds, very juicy, taste resembles somewhat the imported liquorice, with vinegar added. In bunches of 5 to 12 on each stem, on very short fruit stalks. Food value slight.

In damp or moderately dry deep soil in shady or partly open woods. Generally distributed, and in some places abundant.

36. Taxus baccata L. Var. *Canadensis* Marsh. American Yew, Ground Hemlock.

Stems 2 in. to 6 in. long, reclining and often thickly tangled, evergreen; bark and foliage resembles the large hemlock, except that the needles are larger. Berries round, the size of a large

pea, smooth and tender skinned, pulp colorless, resembling uncooked white of egg, juicy, sweetish, pleasant taste, large cup-shaped hollow in top containing a single hard smooth greenish seed, thus differing from every other Nova Scotian fruit. Berries scattered, growing on main stems rather than on branches. Digestible, but not abundant enough to count on as a food supply in a time of need.

In cool damp woods and ravines. Resembles a cone-bearing bush and therefore may be passed without notice. Most abundant in the western counties.

37. Empetrum nigrum L. Black Crowberry, Heath-berry.

Slender dark-colored spreading vines, many branched, ends erect 2 in. to 4 in. high. Leaves oblong, not pointed, scarcely $\frac{2}{10}$ in. long, set thickly along stems. Berries black, size of small peas, juicy, with mild sweetish taste somewhat like sarsaparilla berries, 6 to 9 seeds, palatable, though not of great value as a food.

In great abundance on dry savannas or undulating open barrens where the soil is thin. Widely distributed throughout Nova Scotia, especially the eastern part.

38. Streptopus roseus Mx. Rosy-flowered Twisted Stalk.

Annual, branching stem, 10 in. to 20 in. high, green tender stalk slightly bent at each leaf stalk. Its 2 to 4 branches often assume an umbrella-like form, being curved outwards and drooping at ends. Leaves, long, oval, taper-pointed at both ends, $1\frac{1}{2}$ in. to 3 in. long, light green, tender, finely haired, longitudinally ribbed, growing close to stems, alternate, 10 to 20 on each plant. Berries oval to almost round, $\frac{3}{10}$ in. to $\frac{5}{10}$ in. long, red, smooth-skinned, with pulp like white of egg in appearance, very juicy, with several large white seeds, hanging singly or in twos to thread-like fruit stalks to the number of 8 or 10 on each plant, almost tasteless.

In damp or cool shady woods. Generally distributed, but not very plentiful. Unimportant as a food.

S. amplexifolius D. C., with clasping leaves, whitish underneath, and greenish-white flowers; has similar oval berries, slightly larger.

39. Crataegus coccinea L. Scarlet Thorn, Hawthorn-berry.

Bush 4 ft. to 8 ft. high with small thorns, many branched. Leaves oval, somewhat lobed, thin, sharply notched, truncated base. Berries light coral red, slightly oval, with some seeds, light colored mealy pulp, mild sweetish sour, edible but not important as an article of food.

In dry soil in low woods. Generally distributed; most plentiful near coasts and settlements.

40. Cratægus tomentosa L. Black-thorn, Pear-thorn, locally "Thornberry."

Low tree, 4 ft. to 12 ft. high, many branched, with thorns $1\frac{1}{4}$ in. to $2\frac{1}{4}$ in. long. Leaves larger than last species, oval, sharply notched, abruptly narrowed at base. Berries light scarlet, round, or slight pear-shaped, few seeds, $\frac{1}{2}$ in. thick, pulp pinkish-white, moist though mealy, pleasant tasting and easily digested.

On rocky river banks in burnt or open woods. Generally distributed, but not very abundant.

ROOTS AND BULBS.

41. Apios tuberosa Mœnch. Ground-nut, Indian Potato, "Indian-bean."

A reclining and climbing vine. Leaflets 5 to 7 on each leaf stalk, round base, taper-pointed, 2 in. to 3 in. long, dark green. Blossoms brownish purple, pea-shaped, in cluster along flower stalk. Pods pea-shaped and many-seeded. Flowers early in September. Long roots, swelling into tubers resembling sweet

potatoes. Tubers grey, 1 in. to 2 in. long. Roots, 2 ft. to 16 ft. long, containing from five to fifty tubers. Each plant has several roots. Tubers tough and albuminous, somewhat strong tasting, but not more so than some cultivated potatoes. Nourishing, but needs much cooking. Parboil with salt, then roast. In dry intervale and rocky lake and river banks; but never far above water level, and never in the shade. Available any time.

Plentiful in western Nova Scotia. Have never seen it east of Halifax, though it may exist there.

42. Aralia trifolia Decaisne. Dwarf Ginseng, Ground-nut.

Annual, 3 in. to 4 in. hign, 3 leaf stalks at two-thirds height. Leaflets 3 or 5, oblong, narrow, taper-pointed, notched on margin. Flowers in close set bunch at top of stem, white; blooms in latter part of May. Tubers set deep in ground at end of long tender white stalk, round, white, with 2 or 3 minute rootlets, starchy, pungent sweetish taste. Passable as a food only in extreme cases. Cut open and boil well.

43. Dentaria diphylla Michx. Two-leaved Toothwort, Pepper-root.

From 4 to 12 in. high, divided into 2 or 3 leaf stalks of 3 leaflets each. Leaves, roughly oval, coarsely toothed on margin, pointed, dark green. Flowers white. Roots, 3 in. to 7 in. long, irregular in size, $\frac{1}{16}$ in. to $\frac{1}{4}$ in. thick, white, tender, crisp; hot, like pepper, but pleasant when eaten raw.

In rich moist soil in limestone lands and intervales. Generally distributed, but not very abundant.

44. Typha latifolia L. Common Cat-tail, locally " Bulrush."

Stem 2 ft. to 6 ft. high, a tall column of overlying leaves with small central core, l aves long and grass-like. Top of flower stalk ending in a beautiful brown seed spike, 6 in. long, and resembling, when ripe, a cat's-tail. Above this projects the

pollen producing portion of the plant to a height of 4 in. higher. At junction of stem and root is a starchy edible pith, tasting like tapioca. Eat roasted or boiled—but to extract all nourishment dry and grate the root, soak in water or boil, and strain. A valuable food, but not abundant enough to be important.

In quiet, shallow ponds or miry swamps. Common throughout Nova Scotia. Abundant only in some districts.

45. Osmunda cinnamomea L. Cinnamon Fern.

Fronds $1\frac{1}{2}$ ft. to 4 ft. high, springing from a common root. Flowers and seed on a mass of curled fronds in centre. Edible part is core of root which is tender, white and sweet; found just below the surface. Root is massive, scaly, and fimly rooted and difficult to extract. Roasting or boiling in salt improves. Edible part $1\frac{1}{2}$ in. long.

Plentiful in every swamp and wet tract of land throughout the province.

LEAVES.

46. Rumex crispus L. Curled Dock, Sourdock.

Stems $1\frac{1}{2}$ ft. to 3 ft. high, upper part leafless and seed-bearing. Leaves spread from root and base of stem, 5 in. to 12 in. long, pointed, arrow-like, smooth with strongly crimped margins. Seeds with wings, which are heart-shaped or almost round, and nearly $\frac{1}{4}$ in. wide, in long tapering cluster of several hundred at top of stem. Root long, spindle-shaped, vertical, orange-colored.

In fields, pastures, waste lands, in woods around old lumber camps. Very abundant. Leaves tender, somewhat sour, used as a green boiled with salt, pleasant tasting and digestible especially from May to August. Generally distributed.

47. Rumex sanguineus L. var *Viridis*. Bloody-veined Dock, Sourdock.

Stems long, slender, leafless, spring from base of leaves. Leaves long, slender, pointed at both ends, except lower leaves

which are heart-shaped at base, tender, sour, pleasant. Boil in salt as before. Seeds winged, a somewhat triangular oval, rounded at ends.

In waste and cultivated lands, old roads, and lumber camps. Generally distributed and abundant.

48. Taraxacum dens-leonis Desf. Dandelion.

Low spreading leaves, 6 in. by 1 in., irregular, curve-toothed margin, exudes a mikly juice when broken, very bitter, used as green, boiled. Disagreeable to some on account of its rather bitter taste. Flowers cluster golden yellow, composite, 1 in. across, on erect hollow tender stems 2 in. to 6 in. high, seeds downy, closely packed on crown-shaped base to number of 100 to 150.

Very abundant in and around all cultivated lands and roads.

49. Chenopodium album L. Lamb's-quarters.

5 in. to 13 in. high, erect and branching from a central stem. Leaves 1 in. to 2 in. long, pale green, tender, juicy, glistening mealy surface, oblong, pointed at both ends, irregular or notched margin, palatable and pleasant. Boiled as a green for the table. One of the best.

Common in waste and cultivated land, old clearings. Generally distributed. Abundant only in a few places.

50. Oxalis Acetosella L. Common Wood-sorrel.

Leaf and flower stalks spring from a creeping scaly root growing along the surface or beneath the leaves and moss. Leaves, 3 at top of each leaf stalk which is 2 in. to 3 in. high, strongly heart-shaped with wide end toward stalk, $\frac{1}{2}$ in. to $\frac{3}{4}$ in. across, slightly hairy above and below, juicy and sour. Parboil, then boil whole plant with salt. Unimportant as a food. Flowers 5 sepals, 5 petals, 10 stamens, white with pink veins, $\frac{4}{10}$ in. to $\frac{5}{10}$ in. across, each on a separate stalk 2 in. high. Seed

pods hanging, pear-shaped but reversed, brown, $\frac{1}{4}$ in. long, with 8 to 12 seeds.

In deep shady woods. Abundant everywhere.

51. Fagus ferruginea Aiton. American Beech.

Tree 30 ft. to 60 ft. high, spreading branches. Wood dark colored, hard, yearly growths not easily seen. Bark smooth, light grey, without an outer skin. Leaves 2 in. to 4 in. long, ovate, pointed at both ends, coarsely notched ribs start alternately from mid-rib, smooth above, hairy below, especially on edge of leaf, acid and tender when young, soon become bitter and tough, need much boiling and make an indifferent food. Available in May and June.

Abundant on dry land and in deep soil. Generally distributed.

52. Pteris aquilina L. Common Brake, Bracken.

The young curled fronds, when a few inches high, are tender and palatable. Boil well, as asparagus, which it much resembles. Best in May, soon becomes tough. Also *Osmunda cinnamomea* L., Cinnamon Fern, No. 44 preceding.

53. Allium schœnoprasum L. Chives.

Flower stalk 4 in. to 9 in. high, with round bunch of light purple flowers and pointed sepals. Leaves 4 in. to 7 in. high, awl-shaped, hollow, separate from flower stalk, taste and smell like onions or garlic, useful more as a seasoning than as a food.

Found in low wet lands near sea shore or rivers. In northern Nova Scotia. Have not seen it in the southern or western counties.

54. Medeola Virginica L. Indian Cucumber-root.

Stem of plant 1 to $2\frac{1}{2}$ ft. high, bearing a whorl of about six or more several nerved leaves from 2 to 6 in. long, and tapering to each end, about its middle, and a smaller whorl immediately

below an umbel-like cluster of from 2 to 9 greenish-yellow flowers, with it ovary cells and styles in 3's, and its stamens and perianth in 6's. Berries, dark purple, nearly $\frac{1}{2}$ in. in diameter. It grows from a tuber-like root stalk from 1 to 3 in. long, which has a flavor suggesting cucumber.

Not very abundant, and its food qualities not sufficiently tested.

FLOWERS.

55. Rosa blanda Aiton. Early Wild Rose.

Stem branching, with scattered spines, 1 ft. to 4 ft. high, flower stalk smooth. Leaflets, 5 to 7 on each leaf stalk, oblong, pointed, pale green, a little downy beneath, notched on margin. Flowers, 1 to 3 on each flower stalk, petals 5, stamens many, light rose color, fragrant, edible. Seed-pod round, red, smooth, $\frac{1}{3}$ in. to $\frac{1}{2}$ in. thick, many seeded. Blooms in June.

In rocky soil, barrens, and river and lake banks where not too wet. Common in all parts of Nova Scotia.

56. Rosa lucida Ehrhart. Dwarf Wild Rose.

As the description and range of this species is much like the preceding, it is difficuqt to distinguish. The flowers of both being edible, a mistake in identification is of no consequence.

57. Epigæa repens L. Mayflower, Trailing Arbutus.

Trailing matted vines from 6 in. to 24 in. long. Leaves, wide oval, $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. long, bristly inside, evergreen. Flowers at end of leaf stalks in clusters of 3 to 8, tube-like with 5 clefts, bristly inside, stamens 10 with slender filaments, anthers oblong, sepals long, scale-like, pointed, nearly distinct, flowers $\frac{5}{10}$ in. to $\frac{6}{10}$ in. long. Exhales a delicate perfume, white to pink, edible. Blooms in April. Nova Scotia's earliest flower.

In open woods, dry barrens, dry rocky or sandy soil. Abundant everywhere in Nova Scotia under above conditions.

NUTS AND SEEDS.

58. Fagus ferruginea Aiton. American Beech.

Described in No. 50. Nuts 3-sided, abrupt at base, pointed at top, $\frac{1}{3}$ in. to $\frac{1}{2}$ in. long, in pairs, each pair forms a 4-sided pyramid, and are enclosed in a coarse bristly 4-parted husk, open at top, and growing on extremity of branch. Nut shell brown, easily opened, kernel rich, sweet, and easily digested. A favorite food of squirrels. Very abundant in October. Does not produce regularly.

Generally distributed, but most abundant in the eastern counties.

59. Corylus rostrata Aiton. Beaked Hazel-nut, Filbert.

Tree-like, 3 ft. to 6 ft. high, branching near top, root often bent at right angles to stem. Bark, light-brown with light-grey spots, spotted appearance quite noticeable. Leaves oblong or somewhat heart-shaped, $1\frac{1}{2}$ in. to $2\frac{1}{2}$ in., pointed, soft and slightly downy, doubly notched. Nut round or slightly oval, with beaked top and thick shell, $\frac{1}{2}$ in. to $\frac{3}{4}$ in. long, sweet and easily digested. Enclosed in a long bristly husk with ragged end, in the base of which lies the nut. Husks hang singly or in twos with rudimentary husks attached, and when green is juicy and extremely sour.

In dry or moderately dry open woods or barrens. Generally distributed and abundant.

60. Quercus rubra L. Red Oak.

Tree 50 ft. to 90 ft. high, and 1 ft. to 3 in. in diameter, with heavy spreading limbs. Wood heavy, strong, porous when dry, white in outer part with red heart. Bark grey and strongly corrugated, but not so regularly as the ash. Leaves 4 in. to 6 in. long, with 5-pointed lobes. Nuts round with small spur on end, flat base resting a scaly truncated cup. Size $\frac{1}{2}$ in. to $\frac{3}{4}$ in., with large white kernel, very bitter, which almost precludes its use

even in extreme cases, otherwise it would form a valuable article of food. Bitterness can however be modified considerably by boiling in salt or grating finely and soaking in water, and then roasting.

In dry and moderately wet soils. Very abundant in the western counties; rare or absent east of Halifax.

61. *Polygonum convolvulus* L. Black Bindweed, "Wild Buckwheat.

A climbing tree, 3 ft. to 10 ft. long, with slender stem and triangular leaves, long and pointed, climbing through fallen trees and bushes. Seeds very small, black and triangular, with dry starchy kernels. A poor substitute for common buckwheat.

In old clearings and open woods. Abundant in many districts.

62. *Pinus Strobus* L. White Pine.

Tree 60 ft. to 100 ft. high, evergreen and coniferous, with rough corrugated dark grey bark and often sweeping trunk, sometimes heavily branched. Wood white with red heart, softest of Nova Scotia coniferous woods, as well as most durable. No other Nova Scotian tree resembles it. Leaves, five from the same sheath, needle-shaped, $1\frac{1}{4}$ in. to $2\frac{1}{4}$ in. long, cones gently swelled in middle and pointed at outer ends, 4 in. to 5 in. long, Seeds $\frac{1}{8}$ in. to $\frac{3}{16}$ in. long, sweet, soft, slightly resinous, inside of and at base of cone scales, nourishing and easily digested, but not liked much.

In all sorts of soil except the wettest portion of swamps. Generally distributed and often abundant, but difficult to gather Available until spring.

63. *Pinus resinosa* Aiton. Red Pine.

Tree 40 ft. to 70 ft. high, coniferous, straight trunked with branches at right angles to trunk. Bark red, rough, not so regularly corrugated as that of the white pine. Wood harder,

more resinous, and darker in color than that of the white pine Needles, 2 from the same sheath, 3 in. to 5 in. long, and in far larger bunches than the preceding species. Cones pear-shaped, with ends reversed, 1¾ in. to 2½ in. long, with short spurs on lower outside edge of each cone scale. Seeds enclosed at base of scales, ¼ in. long, sweetish, though resinous. Difficult to gather.

On dry barrens or sandy rocky soil. Abundant in western half of province, rarely seen east of Halifax. Available until May.

64. Acer, several species. Maple.

Tree 15 ft. to 60 ft. high. Wood firm, white, durable when dry. Bark black to grey with flaky outer bark. Leaves deeply notched, with radiating ribs ; some species turning many colored in autumn. One species, *A. Pennsylvanicum,* with striped bark, has leaves 5 in. to 8 in. across, turning to a bright yellow. Seeds winged, often in pairs, not always very palatable, are gathered by squirrels when beech and hazel nuts are scarce : are more digestible than pleasant tasting. Ripens in October.

In all but the wettest and poorest soils. Abundant everywhere where conditions are suitable.

FUNGI.

65. Agaricus campestris L. Common Mushroom.

Appearance well-known. Description unnecessary.

Never found in a forest except, perhaps, near an old lumbering camp, Abundant in long settled parts of the country.

66. Lycoperdon. Puff Ball.

1 in. to 1½ in. thick, skin rough and dark grey, without roots. White, dry, pithy or spongy inside, gradually turning black after completing its growth, earthy or musky smell. Parboil

twice. A poor substitute for nuts. Squirrels search for and eat them only when other food is exhausted. Grows just beneath the surface of moss or leaves without any visible sign of their presence, yet the squirrel detects them easily.

In moderately moist soil in shady woods. Widely distributed but not very abundant. Edible from August to October.

[Dr. A. H. MacKay has tested a large number of Nova Scotian species when cooked, some of them superior to the "mushroom." The edible list of fungi is a long one; but it requires an expert to distinguish them. This is very important, for a few common species are terribly poisonous.]

PARASITIC PLANTS.

67. *Monotropa uniflora* L. Indian Pipe, locally "Death-plant."

White semi-transparent stalk, 2½ in. to 5 in. high, with highly organized flower of five petals, without smell, stalk with thin transparent scales or leaflets, tender and almost tasteless. Parboil, then boil or roast, comparable to asparagus.

In dry or moderately dry soil in thick woods, June to August. Generally distributed and abundant.

JUICES AND EXTRACTS.

68. *Acer saccharinum* Wang. Sugar Maple, Rock Maple.

Tree 40 ft. to 60 ft. high, branches usually crooked and irregular. Bark dark grey, rough, flaky and corrugated, but not so much as the oak or ash. Wood extremely hard, fine-grained, and durable when dry. Leaves 3 in. to 5 in. in diameter, deeply notched into 5 unequal pointed lobes with 5 main ribs radiating from centre (turning color in autumn). A sweet sap is obtained by boring or cutting into the tree to a depth of ½ in. to 2 in. A spout of wood is fitted into a cut made below the boring, and this conducts the sap into a wooden trough or dish of birch-bark. It is then boiled down, about 4

gallons of sap making 1 pound of sugar or a larger quantity of syrup. One tree will make from 2 to 5 pounds of sugar a year. Supposed to be superior to cane sugar. Sap runs only in March or April.

In moderately dry soil, though sometimes found in low wet land. Common, though not abundant, except in few districts.

69. *Ledum latifolium* Aiton. Labrador Tea, locally "Indian-tea."

Leaves which grow directly from main stem are oblong, $1\frac{1}{4}$ in. × $\frac{3}{8}$ in., light green, smooth above with light brown woolly growth beneath, margins curved downward. Aromatic, somewhat bitter and pungent, though pleasant. Formerly much used as a substitute for tea, and a remedy for dysentery. Steep 20 to 30 minutes, slightly narcotic. Flowers few, large, white, 5-parted corolla, many stamens and petals though not composite.

In open bogs, savannas, barrens where not too dry, and also in partly wooded swamps. Abundant everywhere.

70. *Gaultheria procumbens* L. Creeping Wintergreen, Mountain Tea, locally "Tea-berry."

For description see No. 12. Leaves often used as a substitute for tea. It, however, requires much boiling. A very pleasant beverage, but somewhat astringent.

71. *Chiogenes hispidula* T. & G. Creeping Snowberry, locally "Maiden-hair, "Capillaire."

For description see No. 11. Leaves and vines steeped for $\frac{1}{2}$ hour makes a pleasant drink.

72. *Fragaria Virginiana* Duchesne. Wild Strawberry.

See No. 19. Leaves a substitute for tea.

73. *Rubus strigosus* Michx. Wild Red Raspberry.

See No. 20. Leaves a substitute for tea.

74. Betula lutea Michx. Yellow Birch.

Tree 40 ft. to 70 ft. high. Wood clear, white, and fine-grained. Tall clean trunk. Bark yellowish-grey when young, becomes dark and rough when old. Leaves elongated heart-shape, pointed, thin, soft, well-ribbed, slightly downy or bristly beneath. The young twigs are very aromatic, resembling tea-berry or creeping snow-berry. These, well boiled, give a delicious flavoring for beer, or a substitute for tea.

On dry deep soil. Very abundant everywhere.

75. Juniperus Sabina L. var. *procumbens* Pursh. Creeping or Ground Juniper.

A thick, prickly recumbent bush, with hard curved needles ½ in. long, light green above and greenish-white below. Low, spreading over large spaces, with many herby, resinous, slightly bitter seedy berries, which turn from light green to blue when ripe. Used as a blood purifier and a substitute for tea, as well as a flavoring for beer.

On dry open ground, barrens, or sandy stony plains and slopes. Abundant.

76. Rhus typhina L. Staghorn Sumach.

Large shrub or tree, 5 ft. to 20 ft. high. Moderately rough greyish-green bark. Stems once used for dyeing. Consists of an outer layer of nearly white wood. covering large core of deep greenish-yellow color, unlike any other Nova Scotian tree in this respect. Branches few and massive. Leaves 3 in. to 5 in. long and ½ in. to ¾ in. wide, pointed at both ends, strongly notched, soft, hairy above and below, especially the latter, arranged in regular order along the sides of long leaf stalks, the whole showing at a distance as a beautiful feathery mass of foliage. Seeds oval, size of truncated grains of barley, hard, covered with minute purplish-red bristles. These are impregnated with an intensely sour juice from which a pleasant acid

beverage is extracted by boiling. They grow close set in bunches, resembling at a distance rough tapering pods, each 3 in. to 5 in. long and 1 in. to $1\frac{1}{2}$ in. thick. Each bush carries from 2 to 20 seed clusters. These clusters in the fall become much infested by worms.

Generally distributed, but much rarer in the eastern than in the western counties. Particularly abundant in the interior of Yarmouth county.

77. *Geum rivale* L. Purple or Water Avens, "Wild Chocolate."

A single erect stem, 6 in. to 12 in. high, with drooping peculiar purple flower $\frac{1}{2}$ in. in diameter. Full of stiff hairy bristles projecting beyond the short round petals. One or two leaflets on flower-stalk. Leaves, 3 or 4, spring from root around flower-stalk, resemble geranium leaves, but are thinner, though they perhaps are more like the leaves of the Bake-apple. See No. 22. Roots from 2 in. to 6 in. long, and $\frac{1}{4}$ in. thick, dark purplish-brown inside, with many rootlets. Taste somewhat like chocolate, but astringent with a very slight addition of acid. Was once used as a substitute for chocolate. Boil well, and add sugar.

Common in open mossy bogs in eastern Nova Scotia, more rare in the western counties.

A Section of Carboniferous Rocks in Cumberland County. Nova Scotia: (1) Detailed Section of Rocks from West Ragged Reef to the Joggins Mines and Minudie, by Sir William E. Logan, (republished); and (2) from Shulie to Spicer Cove, by Hugh Fletcher, B. A., of the Geological Survey of Canada.

Introduction.

By Henry S. Poole, D. Sc., F. G. S.,
President of the N. S. Institute of Science.

The continuous exposure of Carboniferous rocks along the Cumberland County shore of the Bay of Fundy, Nova Scotia, early attracted the notice of observers, and in 1843 it was measured in detail by the late Sir William Logan. His section of 14,570 feet of strata was published in 1845 as an appendix to the Reports on a Geological Survey of the Province of Canada.* Copies of this section, however, cannot now be obtained. Students ask for them and so do others who are attracted to the locality by the present boom in the coal trade and the possibilities of the field whose rocks are so well exposed in the so-called Joggins section.

To meet this demand, the council of the Nova Scotian Institute of Science has decided to republish Logan's section *verbatim et literatim.* Following the reprint of this section is given, with the sanction of Dr. R. Bell, the Acting Director of the Geological Survey of Canada, a hitherto unpublished detailed section of the rocks from Shulie to Spicer Cove, by Mr. Hugh Fletcher, who has made a life's study of the geology of

* Message from His Excellency the Governor General, with Reports on a Geological Survey of the Province of Canada, presented to the House on 27th January, 1845. Montreal, 1845.

Nova Scotia. That gentleman has also taken great trouble to prepare the accompanying map. *

The base of the section is occupied by rocks of the Carboniferous Limestone series. They form an anticline from the shore of the Bay of Fundy opposite Shepody Mountain across the country to Pugwash on the Straits of Northumberland. Resting on them, with a southerly dip towards the Cobequid range, approximately parallel to the anticline, lies the series of strata detailed in this section. Going southward, in ascending order, the highest members are reached at Shulie, and there Logan's section ended. Mr. Fletcher continued his examination, over the repeated measures to the flank of the hills, where at Spicer's Cove a continuous bed of conglomerate, the waste of the igneous rocks of the axis of the range, terminates the area under review.

The best exposure of the base of the Joggins series is on the west side of Maringouin peninsula where at the Pink Rocks the gypsum deposits are closely overlaid by marine fossiliferous limestones and marls dipping southerly. Then succeeds the series of the Middle Carboniferous, of red sandstone, shales and marly beds, in turn overlaid by the unbroken grey beds with which are associated some bitumenous shales and dark fireclays with small seams of coal from Ferris Cove to the Squaw's Cap, a repetition of the measures of the Joggins section north of Boss Point on the other side of Cumberland Basin.

The portion of the series remaining on the point of the peninsula, can be traced across Shepody Bay through Grindstone Island and Mary Point, where the strata are deflected to skirt the New Brunswick coast to Cape Enragé.

A visitor to the Pink Rocks on Maringouin will find a partial repetition to the northward, and structural features well

* The Nova Scotian Institute of Science takes this opportunity to acknowledge on behalf of the practical and scientific interests of the province, the public appreciation of the work performed by Mr. Fletcher, and of the zeal he has brought to bear on the study of our much complicated rock structure and the compilation of details relating to Nova Scotia.

worthy of examination. There is at Hard Ledge an exceptionally well exposed syncline with its axis inclined 15° towards Shepody Mountain, and an unconformity with members of the so-called Permian series. When in the neighborhood one should not fail to see The Rocks of Demoiselle Cape below Hopewell; conglomerate cliffs, caved by the sea, and on a grand scale carved into pinnacles and buttressed.

Mill Cove, the base of Logan's measurements, lies opposite Minudie, and between them, it is said, gypsum beds occur agreeing with the horizon of the Pink Rocks of Maringouin.

Section of the Nova Scotia Coal Measures, as developed at the Joggins, on the Bay of Fundy, in descending order, from the neighbourhood of the West Ragged Reef to Minudie, reduced to vertical thickness.

[Made by SIR WILLIAM E. LOGAN, in 1843 and published as an appendix in the first Report of Progress of the Geological Survey, for 1843, beginning at page 92, and extending to page 156, with figures on pages 157 to 159.]

1.

	Ft.	In.
Greenish gray or drab coloured sandstone or grit, with some conglomerate beds, of which the matrix is sandstone and the pebbles consist of white and of red veined quartz. These are generally as large as peas; some are of the size of pigeons' eggs, and a few as large as hens eggs, ...	30	0
Drab sandstone of a fine grit, but rather too hard for grindstones,........	2	0
Red or chocolate coloured argillaceous shale, with small layers of sandstone of the same colour and quality as above,...................	15	0

	Ft.	In.
Drab sandstone, with small layers of chocolate coloured shale,............................	20	0
Dark red argillaceous shale, with some green spots,....	10	0
Drab sandstone in two to three beds,................	8	0
Drab sandstone of a coarse grit ; the bed has an uneven bottom,............................	20	0
Dark red or chocolate coloured argillaceous shale, with a few bands of sandstone,....................	20	0
Dark red argillaceous shale,.....................	10	0
Drab sandstone,..............................	7	0
Dark red shale and drab sandstone in irregular beds ,..	20	0
Drab or greenish gray sandstone,.................	3	0
Red argillaceous shale,........................	9	0
Greenish gray or drab coloured sandstone in several layers, separated by bands of dark red or chocolate coloured argillo-arenaceous shale................	20	0
Greenish gray or darb coloured sandstone of a fine grit,	4	0
Soft measures, concealed, probably dark red shale,.....	20	0
Coarse greenish gray sandstone, or rather a conglomerate with a fine matrix of sand and with fragments of plants, converted into coal,.....................	30	0
Measures not well seen,.........................	15	0
Greenish gray sandstone, with conglomerate beds and plants converted into coal,......................	60	0
Dark red shale,.............................	15	0
Greenish gray sandstone, with conglomerate beds,......	10	0
Dark red shale,.............................	5	0
Greenish gray or darb coloured sandstone, with conglomerate beds,..............................	15	0
Dark red shale,.............................	10	0
Greenish gray sandstone, with conglomerate beds,......	52	0
Dark red shale, with bands of red sandstone,..........	14	0
Greenish gray sandstone, with conglomerate beds,.....	25	0
Dark red shale,.............................	10	0

	Ft.	In.
Greenish gray sandstone, with plants converted into coal,	30	0
Dark red shale, with thin beds of sandstone,.........	10	0
Greenish gray sandstone, with thin conglomerate layers,	3	0
Dark red shale,..............................	6	0
Greenish gray sandstone, with beds of conglomerate,...	55	0
Dark red or chocolate coloured shale,................	1	0
Greenish gray sandstone, with much conglomerate and fragments of drift plants coated with coal,..........	50	0
Dark red or chocolate coloured shale,................	9	0
Greenish gray sandstone, with conglomerate beds and carbonized drift plants,........................	14	0
Dark red shale,................................	5	0
Dark red shale, with beds of sandstone, ...	15	0
Greenish gray sandstone, with conglomerate beds,.....	20	0
Greenish gray sandstone, with bands of red shale,......	21	0
Greenish gray sandstone, with conglomerate beds and carbonized drift plants of large diameter, say one foot, and wholly converted into coal. In many cases the action of the surf against the base of the perpendicular cliff has worn deep holes or caverns, where the stems lie prostrate in the reck. The plants are *sigillariæ*, so are nearly the whole of those already mentioned as met with in the grits or conglomerates. Fragments of *calamites* are occasionally seen,.	30	0
Red or chocolate coloured shale,.....................	10	0
Greenish gray sandstone of a conglomerate character, with many carbonized drift plants imbedded in it. Some beds of grit in this, towards the bottom, have been found fit for grindstones, ...	20	0
Dark red or chocolate coloured argillaceous shale,......	60	0
Greenish gray sandstone inclining to yellow, chiefly of a coarse grit and free texture; some of it must be called conglomerate, the pebbles of which, consisting of quartz of various colours—white, yellow, and red,		

	Ft.	In.
with black chert and lydian stone,—are some of them as large as hens' eggs, a great many as large as almonds, and the majority as big as peas. Some of the beds have been found fit for grindstones. This sandstone constitutes the point of *West Ragged Reef*,*	30	0
Measures concealed,	42	0
Measures concealed, with sandstone at the bottom,	23	0
Greenish gray or drab coloured sandstone of a coarse grit,	12	0
Dark red shale with green bands,	30	0
Greenish gray sandstone of a coarse grit, some of which is fit for grindstones, but some parts are conglomerate, with red and white quartz pebbles, generally as large as peas, some of the size of pigeons' eggs, and a few as large as hens' eggs; some parts exhibit large spherical concretions rather harder than the surrounding material,	30	0
Dark red shale, with green bands,	6	0
Greenish gray or drab coloured sandstone of a coarse grit,	6	0
Dark red and light green shale, with some bands of drab sandstone,	50	0
Greenish gray sandstone of a coarse grit,	30	0
Dark red shale,	30	0
Greenish gray sandstone of a coarse grit, with some carbonized drift plants,	3	0
Greenish and red shale. This is on the west side of *South Brook, Two Rivers*,	3	0
Measures not well seen, being occupied by the brook, but consisting chiefly of greenish gray sandstone,	42	0
Greenish gray sandstone, with bands of greenish arenaceous shale and red arenaceous shale,	10	0
Red argillaceous shale,	1	0
Greenish gray sandstone,	7	0
Red arenaceous shale,	4	0

*In this reprint, place names are printed in a more prominent type than in the original, in order to facilitate reference to the section.—*Editor.*

	Ft.	In.
Red argillaceous shale,	6	0
Red argillo-arenaceous shale,	17	0
Greenish gray sandstone,	2	0
Red argillo-arenaceous shale,	2	0
Greenish gray sandstone,	1	0
Red argillo-arenaceous shale,	18	0
Greenish gray sandstone,	7	0
Red argillo-arenaceous shale,	6	0
Greenish gray sandstone,	1	0
Red argillo-arenaceous shale, with green bands,	8	0
Greenish gray sandstone of a coarse grit,	19	0
Measures concealed. This is where the *North Branch of the Two Rivers* occurs,	16	0
Greenish gray sandstone of a coarse grit, with some beds of conglomerate, having red and white quartz pebbles, the largest of which would weigh about two ounces,	20	0
Red argillaceous shale,	12	0
Greenish gray sandstone of a coarse grit, some parts of which are fit for large grindstones, commonly called *water-stones* by the quarrymen,	76	0
Greenish gray sandstone, with divisional layers of arenaceous shale,	4	0
Red argillaceous shale,	19	0
Red argillaceous shale, with greenish gray arenaceous shale at the top,	19	0
Greenish gray sandstone,	1	0
Red argillaceous shale,	4	0
Greenish gray sandstone,	2	0
Red argillaceous shale,	6	0
Greenish gray sandstone,	5	0
Red argillaceous shale and green arenaceous shale, with a few bands of greenish gray sandstone. This deposit is chiefly red shale,	32	0
Greenish gray sandstone,	24	0

	Ft.	In.
Red argillaceous shale with green bands,............	10	0
Greenish gray sandstone in four beds, separated by bands of red argillaceous shale of one to two feet thick,....	27	0
Red argillaceous shale,...........................	11	0
Greenish gray sandstone, with one foot of shale towards the bottom,....	5	0
Red argillaceous shale,.....	8	0
Greenish gray sandstone in three small beds separated by red shale; occasionally the sandstone occupies the whole of the thickness.....	5	0
Red argillo-arenaceous shale, with green bands,........	27	0
	1617	0

Recapitulation.

Greenish gray or drab coloured sandstones, with conglomerate beds and large carbonized drift plants,......	947	0
Dark red or chocolate coloured argillaceous and argillo-arenaceous shales,...	670	0
	1617	0

2.

Gray arenaceous shale,........................	5	0
Greenish gray sandstone. This is an unequal band, and there are doubtful indications of the leaves of *stigmariæ ficoides* at the top, ...	8	0
Reddish and greenish gray argillaceous shale, with some bands of arenaceous shale,.....................	28	0
Greenish gray sandstone of a coarse grit fit for water-stones,................	7	0
Red argillaceous shale, with some bands of arenaceous shale.	5	0
Measures concealed,............	26	0
Greenish gray sandstone,..........	3	0

	Ft.	In.
Measures only partially seen, and containing some arenaceous shale,..........	13	0
Reddish yellow sandstone,..........	2	0
Measures concealed, but shown by the shape of the surface to be soft,..........	4	0
Reddish yellow sandstone of a coarse grit, fit for water-stones,..........	15	0
Red argillaceous shale,..........	7	0
Reddish yellow sandstone of a coarse grit, fit for water-stones,..........	12	0
Red argillaceous shale, with greenish gray arenaceous shale in three beds,..........	47	0
Greenish gray sandstones,..........	7	0
Red argillaceous shale,..........	3	0
Greenish gray sandstone,..........	14	0
Dark green shale,..........	1	0
Gray sandstone,..........	25	0
Red argillo-arenaceous shale, with greenish gray arenaceous shale, and some few layers of sandstone,......	42	0
Greenish gray sandstone,..........	9	0
Greenish gray arenaceous shale and sandstone, with red and gray argillaceous shale,..........	24	0
Red argillaceous shale, with green arenaceous shale,....	26	0
Gray sandstone fit for grindstones,..........	21	0
Red and green shale,..........	11	0
Greenish gray sandstone,..........	4	0
Red argillaceous and arenaceous shale,..........	5	0
Greenish gray sandstone of various qualities, chiefly of coarse grit, fit for large grindstones or water-stones; much of it, however, is fine enough for small stones; both are made from the Reef,..........	97	0
Red argillaceous and greenish gray arenaceous shale,...	13	0
Gray sandstone fit for grindstones, the bottom part of a coarse grit. This constitutes *Ragged Reef Point*,....	35	0
Red argillaceous shale,..........	15	0

	Ft.	In.
Greenish gray sandstone, fit for grindstones,..........	10	0
Red argillaceous shale, with one foot of greenish gray sandstone,......	9	0
Greenish gray sandstone fit for grindstones ; the top of the bed is uneven,......	20	0
Red argillaceous shale, gray arenaceous shale, and a few bands of greenish gray sandstone,.........	15	0
Red argillaceous shale,..............................	4	0
Greenish gray sandstone,.............................	2	0
Red argillaceous shale, with green bands, ...	13	0
Greenish gray shaly sandstone, or perhaps arenaceous shale,.	7	0
Greenish gray sandstone fit for grindstones, with a few *calamites* nearly at right angles to the plane of the beds, as if in situ, but forced over at the top,........	36	0
	650	0

Recapitulation.

	Ft.	In.	Ft.	In.
Drab coloured sandstones without conglomerate beds,............................	219	0		
Gray sandstones,.	81	0		
Reddish yellow sandstones,................	28	0		
			328	0
Red, green and greenish gray argillaceous and arenaceous shales,............			322	0
			650	0

(Indications of *stigmariæ ficoides* exist near the top, and of upright *calamities* at the bottom.)

3.

	F.	In.
Black carbonaceous shale	2	0
Greenish gray sandstone, with *stigmariæ ficoides*, (this would be called *understone* by the Welsh miners)	3	0
Gray argillaceous shale, with impressions of *ferns* and other plants, (*topstone*)	2	0
1. COAL of inferior quality—a regular seam	0	1
Greenish gray argillaceous shale, with *stigmariæ ficoides* (*understone*)	1	0
Greenish gray argillaceous shale, with *stigmariæ ficoides* and *ironstone* balls (*understone*)	1	0
Greenish gray sandstone	1	0
Red or chocolate coloured shale	6	0
Greenish gray sandstone, fit for grindstones, with a bed of red shale in the middle	23	0
Red shale, with a layer of sandstone	12	0
Red shale, in three beds	5	0
Greenish gray sandstone, in four beds	6	0
Red argillaceous shale	7	0
Gray sandstone, in small layers	7	0
Reddish gray sandstone	3	0
Greenish gray sandstone, in small layers	7	0
Reddish and green sandstone	13	0
Reddish and green shale	1	0
Reddish sandstone—soft	1	0
Red argillo-arenaceous shale, with balls of *ironstone*	3	0
Red and green sandstone	12	0
Measures concealed, but supposed to be soft	52	0
Red and green shale, with balls of *ironstone*	7	0
Gray sandstone and shale	3	0
Greenish gray sandstone	8	0
Greenish gray sandstone and red shale	5	0
Greenish gray or drab coloured sandstone, fit for grindstones	50	0

			Ft.	In.
Red shale			8	0
Greenish gray or drab sandstone, fit for grindstones; the top is uneven, and the whole is rather of a coarse grit. This constitutes *South Ragged Reef*			20	0
Red shale			7	0
Reddish gray sandstone			9	0
Red argillaceous shale			3	6
2. COAL	0	1		
Dark gray carbonaceous shale	0	4		
COAL	0	1		
			0	6
Red shale; the upper part is of a tough quality, and has *stigmariæ ficoides* in it (*understone*)			13	0
Greenish gray or drab coloured sandstone, occasionally separated into two beds. This sandstone appears to thin out within the distance of 100 yards on the strike			33	0
Red shale			2	9
Greenish gray or drab coloured sandstone			5	0
3. COAL			0	1
Greenish gray sandstone and reddish shale, with *stigmariæ ficoides* (*understone*)			5	0
Reddish green argillaceous shale			1	0
4. COAL			0	2
Reddish and green argillaceous and arenaceous shale, the green colour prevailing, with *stigmariæ ficoides* (*understone*)			5	0
Reddish and green argillaceous and arenaceous shale, the red prevailing			6	0
Red shale, separated by thin bands of sandstone; the top is of the tough crumbly quality of underclay, but no *stigmariæ* are visible			20	0
Gray sandstone and shale, the sandstone of soft quality			11	0
Dark red shale			0	6

	Ft.	In
Tough arenaceous shale, with *stigmariæ ficoides* in the upper part in two layers, a hard and a soft one (*understone*)	12	0
Red and green crumbly tough shale of the quality of underclay, but no *stigmariæ* visible	11	0
Greenish gray sandstone, in four thinly laminated divisions, separated by red and green shale	30	0
Gray sandstone and red shale in thin beds	10	0
Red and green shale	9	0
Greenish gray sandstone, with red and green shale	4	0
Greenish gray sandstone, in regular beds of three feet and upwards	17	0
Red shale, varying from two to seven feet thick	5	0
Greenish gray sandstone	4	0
Greenish shale	1	0
Gray sandstone and shale	4	0
Dark greenish red shale	2	0
Greenish gray sandstone	1	0
Dark green and red shale	1	0
Greenish gray or drab coloured sandstone, fit for grindstones, forming a reef	25	0
Reddish shale	8	0
Greenish gray sandstone, in three beds, and gray shale in beds of one foot each	20	0
Gray shale, with two beds of greenish gray sandstone of one foot each	20	0
(Into the above penetrate two upright stems (*calamites*), two inches in diameter; and replaced by sandstone with a coating of coal; they start from the top of the succeeding bed.)		
Dark gray argillaceous shale	8	0
5. COAL	0	2
Gray argillo-arenaceous shale (*fire clay?*) with *stigmariæ ficoides* (*understone*)	1	6

		Ft.	In.
Gray argillo-arenaceous shale		10	0
Gray sandstone		1	0
Gray arenaceous shale, in two equal beds		7	0
6. COAL		0	3
Gray argillo-arenaceous shale, with *stigmariæ ficoides*		2	0
Greenish gray sandstone		2	0
Gray argillaceous shale		1	0
Gray argillaceous sandstone, with *stigmariæ ficoides* (*understone*)		2	0
Gray argillaceous shale		3	0
Reddish gray sandstone		1	0
Gray argillaceous shale		1	6
(In this shale, and running into the sandstone above, is visible a *calamite* at an angle of 45° to the plane of the deposit. It appears to start from the coal below.)			
7. COAL	0 1		
Gray argillaceous shale, with *stigmariæ ficoides* (*underclay*)	1 6		
COAL	0 2		
Gray argillaceous shale, with *stigmariæ* (*underclay*)	0 4		
COAL	0 1		
		2	2
Gray argillaceous shale, with *stigmariæ* (*underclay*)		2	0
Greenish gray crumbly sandstone, with *stigmariæ* at the top		8	0
Red shale		12	0
Greenish gray sandstone		3	0
Red shale, with some few beds of sandstone		20	0
Red shale and reddish gray sandstone, in beds of one to three feet		12	0
Reddish gray sandstone, in thin layers, alternating with red shale		12	0
Red and green arenaceous shale		4	0

	Ft.	In.
8. COAL	0	1
Gray argillaceous shale, with *stigmariæ ficoides* (*understone*)	3	0
Gray argillaceous sandstone, with *stigmariæ ficoides* (*understone*)	2	0
Hard argillo-arenaceous shale, with *stigmariæ ficoides* (*understone*)	5	0
Red shale	20	0
Greenish gray or drab coloured sandstone, forming a reef	20	0
Red shale	23	0
Reddish gray sandstone	5	0
Red shale and greenish gray sandstone; not much sandstone	30	0
Red argillaceous shale and greenish gray sandstone, more sandstone than before	30	0
Red argillaceous shale	1	0
Reddish gray sandstone	1	0
Red argillaceous shale	3	0
Reddish gray sandstone	2	0
Red argillaceous shale	12	0
Greenish gray sandstone	15	0
Red argillaceous shale	20	0
Reddish sandstone	2	0
Red and green shale	8	0
Reddish gray sandstone	6	0
Red shale	2	0
Greenish gray sandstone	2	0
Red argillaceous shale	3	0
Greenish gray sandstone	3	0
Greenish gray sandstone, fit for grindstones, which are now quarried from it. This constitutes *North Ragged Reef*	12	0

	Ft.	In.
Reddish gray sandstone, in beds of one to three or four feet, separated by beds of reddish shale of one to two feet	60	0
Red shale	4	0
Reddish sandstone	2	0
Red argillaceous shale	20	0
Greenish gray sandstone, in beds of two to three feet, with beds of red shale of one to two feet	30	0
Red argillaceous shale	6	0
Reddish sandstone, separated at the top into moderate layers by red shale	49	0
Red shale	2	0
Reddish sandstone	1	0
Red argillaceous shale	35	0
Gray sandstone and red argillaceous shale, in alternating beds; the sandstone has a reddish tinge towards the top	30	0
Gray sandstone	1	0
Reddish argillaceous shale	5	0
Gray sandstone	1	0
Reddish argillaceous shale	5	0
Gray sandstone	2	0
Reddish and gray shale	1	0
Gray sandstone	2	0
Reddish argillaceous shale, with *ironstone* balls	3	0
Gray sandstone	1	0
Green and red argillaceous shale	2	0
Hard argillo-arenaceous shale	1	0
Gray argillaceous shale, with *ironstone* balls. This bed has something the appearance of underclay, but the *stigmariæ* are not distinct	7	0
9. COAL	0	3
Gray arenaceous shale, with *ironstone* balls, and *stigmariæ ficoides* (*underclay*)	5	0

			Ft.	In.
Reddish gray argillaceous shale			1	0
10. COAL and *carbonaceous shale*	0	8		
Gray argillaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)	2	0		
COAL	0	2		
			2	10
Gray argillaceous sandstone, with *stigmariæ ficoides* (*underclay*)			2	0
Reddish and green argillo-arenaceous shale, *ironstone* balls. This has much the character of underclay, but the *stigmariæ* are not well marked			12	0
Gray sandstone			1	0
Gray argillaceous shale, with *ironstone* balls			3	0
Greenish gray sandstone			4	0
Gray argillaceous shale			1	0
(From the succeding layer of coal there springs up an erect *sigillaria*. It is 1 ft. 6 in. in diameter, and penetrates the shale and sandstone above it, five feet of the plant being visible.)				
11. COAL			0	3
Gray sandstone, with *stigmariæ ficoides* (*underclay*)			2	0
Gray argillaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)			5	0
12. *Black carbonaceous shale*	0	9		
COAL	0	2		
			0	11
Gray argillaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)			1	6
Greenish gray sandstone			1	6
Gray argillaceous shale			9	0
13. COAL			0	7
Gray argillaceous shale, with *ironstone* balls and *stigmaria ficoides* (*underclay*)			2	0
Gray argillaceous shale			5	0

			Ft.	In.
14. COAL	0	4		
Gray argillo-arenaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)	1	6		
COAL	0	2		
			2	0
Gray argillaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)			7	0
Gray argillo-arenaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)			1	0
Greenish gray sandstone			1	0
Greenish gray sandstone and red and gray argillo-arenaceous shale. The sandstone is not in thick beds. *Ironstone* balls and *stigmariæ ficoides* are found through the whole deposit			40	0
Greenish gray argillaceous shale			3	0
15. *Carbonaceous shale*	0	2		
Gray argillaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)	1	0		
COAL	0	1		
			1	3
Gray argillaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)			3	0
Greenish gray sandstone, with three bands of red and gray shale, loaded with *ironstone* balls			12	0
Gray argillaceous shale			1	0
16. COAL and *carbonaceous shale*			0	2
Red argillaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)			7	0
Greenish gray sandstone			10	0
Red and green shale			2	0
Rough gray argillaceous sandstone			2	0
Red and green shale			2	0
Rough greenish gray argillaceous sandstone			1	6
Red and green shale			2	0

					Ft.	In.
Greenish gray sandstone					5	0
Red and green argillaceous shale					7	0
17. COAL			0	1		
Gray argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)			4	0		
COAL	0	4				
Carbonaceous shale	0	4				
COAL	0	1	0	9		
					4	10
Gray sandstone, with 3 inches of soft gray argillaceous shale at the top, and penetrated by *stigmariæ ficoides* (*understone*)					1	3
Gray argillo-arenaceous shale					1	0
18. COAL					0	3
Gray arenaceous shale, with *stigmariæ* (*underclay*)					2	0
Gray arenaceous sandstone, with *stigmariæ* (*underclay*)					2	0
Red and green shale					3	0
Greenish gray sandstone, in several layers					6	0
Red and green argillaceous shale					7	0
Gray sandstone, with *stigmariæ* (*understone*)					2	0
Red and green argillo-arenaceous shale					4	0
19. COAL					0	1
Red argillaceous shale, with *stigmariæ* (*underclay*)					4	0
Greenish gray sandstone and red shale alternating, the sandstone in 7 beds of 2 to 8 feet, the shale in 5 beds of ½ to 3 feet					60	0
Red and gray argillaceous shale					13	0
Greenish gray sandstone					2	0
Greenish gray shale and sandstone					2	0
Greenish gray sandstone					2	0
Greenish gray shale					2	0
Greenish gray sandstone					2	0
Measures concealed					41	0

	Ft.	In.
Greenish gray sandstone	1	0
Measures concealed	1	0
Greenish gray sandstone	2	0
Measures concealed. Here occurs DENNIS RIVER*	9	0
Greenish gray sandstone	3	0
Measures concealed, but supposed to be shale	4	0
Greenish gray or drab coloured sandstone, fit for grindstones. There are quarries in it on the SOUTH REEF, DENNIS RIVER	25	0
Red argillo-arenaceous shale	9	0
Greenish gray or drab coloured sandstone, fit for grindstones. Some are quarried from the bed on the NORTH REEF, DENNIS RIVER	18	0
Measures concealed, but supposed to be argillaceous shale	4	0
Greenish gray or drab sandstone, almost fit for grindstones	14	0
Greenish gray argillaceous shale	1	0
Greenish gray sandstone	2	0
Dark gray argillaceous shale	1	0
20. COAL	0	1
Red and green shale, with *stigmariæ ficoides* (*underclay*)	1	0
Greenish gray sandstone	1	0
Red and greenish gray argillaceous shale, with *ironstone* balls	6	0
Carbonaceous shale	0	3
Gray crumbly argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)	2	0
Greenish gray sandstone	1	0
Reddish shale, with *ironstone* balls	1	0
Greenish gray sandstone	4	0
Red argillaceous shale, with *ironstone* balls	23	0

* Now McCarren's Brook.—*Editor.*

	Ft.	In
Greenish gray sandstone, with red and green shale studded with *ironstone* balls	4	0
Red and greenish gray argillaceous and arenaceous shale, in beds of five feet, with greenish gray sandstone, in beds of one to three feet	30	0
Reddish and greenish gray argillaceous shale, with *ironstone* balls	15	0
Greenish gray sandstone, soft, with bands of red arenaceous shale	21	0
Red argillaceous shale	2	0
21. COAL	0	2
Greenish gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)	2	0
Measures concealed	35	0
Greenish gray sandstone of good grit	4	0
Measures concealed	7	0
Greenish gray sandstone of good grit	1	0
Measures concealed	15	0
Greenish gray arenaceous shale	1	0
Measures concealed	43	0
Measures concealed, but probably sandstone	7	0
Measures not perfectly seen, but consisting in part of greenish gray sandstone	13	0
Greenish gray sandstone, with impressions and casts of *calamites*. This layer is almost fit for grindstones, but not sufficiently regular to be worked profitably	13	0
Measures not well seen, supposed to be red shale	22	0
Red and greenish gray argillo-arenaceous shale, the red prevailing, with some bands of greenish gray sandstone of six to twelve inches	40	0
Reddish and greenish gray sandstone, in beds of three to ten feet, separated by layers of red and greenish gray arenaceous shale of one to two feet. This forms DENNIS RIVER POINT	31	0

	Ft.	In.
Greenish gray sandstone, soft and ragged, in aggregated beds of one to ten feet; the aggregations separated by beds of dark red and green argillaceous and arenaceous shale of one to two feet, having *ironstone* balls; impressions of plants, among them *sigillariæ* and *calamites,* prevail in the sandstone	60	0
Dark red and green argillaceous shale, with six beds of red and greenish gray sandstone; the shale is loaded with *ironstone* balls	40	0
22. COAL *and carbonaceous shale*	0	2
Gray argillo-arenaceous shale of a tough quality, with *stigmariæ* (*underclay*)	4	0
Dark red and green argillaceous shale, with a band of sandstone	16	0
Gray argillaceous and arenaceous shale, with *ironstone* nodules and some thin beds of sandstone	10	0
Gray sandstone, with *stigmariæ* (*understone*)	2	0
Dark gray shale, with *ironstone* nodules	22	0
Gray sandstone	1	0
Gray argillaceous shale	2	0
Gray sandstone	1	0
Greenish gray arenaceous shale	6	0
Gray sandstone, in layers of four inches each	4	0
	2,134	1

RECAPITULATION.

COAL, in 22 seams	5	5		
Carbonaceous shale associated with the coal seams, and in one instance without coal	3	10		
			9	3

Underclay or understone, being beds of various material, immediately subjacent to the seams of Coal and Carbonaceous shale, and universally penetrated by the branches and radiating leaves of the stigmariæ

ficoides. Every one of the Coal and Carbonaceous seams rests upon a bed of this description, and in two cases stigmariæ beds exist without superincumbent coal. The material constituting the stigmariæ beds is as follows:

					Ft.	In
Sandstone—Gray	23	3				
Drab	43	0				
			66	3		
Argillaceous and arenaceous shale, having often the character of fireclay—						
Gray	58	4				
Greenish gray	7	0				
Red and occasionally green	42	0				
			107	4		
					173	7
Sandstone—Gray	82	0				
Greenish gray, chiefly fit for grindstones	657	0				
Reddish, of various shades	204	0				
					943	0
Shale—Gray-Argillaceous	92	6				
Arenaceous	44	0				
			136	6		
Red and green—						
Argillaceous	564	0				
Arenaceous	104	9				
			668	9		
					805	3
Measures concealed, supposed to be chiefly shale					203	0
					2,134	1

(Among the organic remains visible are one oblique and two upright calamites, and one upright sigillaria. One topstone bed of shale contains impressions of ferns.)

4

			Ft.	In.
1. *Bituminous limestone, with shells* and *fish scales*	4	0		
COAL	1	0		
			5	0
Greenish gray argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)			4	0
Gray sandstone, in courses of six and nine inches, with *ironstone* balls and *stigmariæ ficoides* (*understone*)			2	6
Gray argillaceous shale			1	0
Gray sandstone			6	0
Gray argillaceous shale			1	0
Gray sandstone of a rough texture			1	0
(From the succeeding bed springs an upright stem (*sigillaria*). It widens towards the bottom, and penetrates into the sandstone above.)				
Gray argillaceous shale, with *ironstone* balls			6	0
Gray sandstone and arenaceous shale			5	0
Gray arenaceous shale			2	0
Hard gray arenaceous shale, with *stigmariæ ficoides* (*underclay*)			1	6
Gray argillaceous shale			20	0
2. COAL and *Carbonaceous shale*			1	0
Soft gray argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)			1	0
Hard gray arenaceous shale, with *stigmariæ ficoides* (*underclay*)			2	0
Gray argillaceous shale			1	0
3. COAL and *Carbonaceous shale*			0	3
Hard argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)			2	0
Gray argillaceous shale			4	0

					Ft.	In.
4. COAL	0	9				
Carbonaceous shale	0	6				
COAL	0	1				
Carbonaceous shale	0	4				
COAL	0	1				
Carbonaceous shale	0	8				
COAL	0	2				
			2	7		
Gray argillaceous shale, no *stigmariæ* visible, but across the bed appear two parallel regular cracks, about $\frac{1}{4}$ of an inch wide each, and about 18 inches apart, filled with coal, the fibre of which is at right angles to the cracks. This may be the section of an upright stem			1	7		
COAL			0	8		
					4	10
Hard gray argillo-arenaceous shale with *stigmariæ ficoides* (*underclay*)					4	0
Greenish argillaceous shale, with *ironstone* balls					12	0
Gray sandstone in several layers					1	0
Red and green argillaceous shale, with *ironstone* balls					20	0
Gray sandstone and green shale in alternating layers					24	0
Red or chocolate coloured argillaceous shale					3	6
(From the succeeding bed rises an upright *sigillaria* one foot in diameter; two feet of it are seen penetrating the bed above.)						
Gray argillaceous shale					1	6
Gray sandstone in thin beds					8	0
Gray argillaceous shale					8	0
5. *Bituminous limestone*, with *shells*			2	0		
COAL			0	0½		
Gray argillo-arenaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)			0	6		
Carbonaceous shale			0	0½		

			Ft.	In.
Gray argillo-arenaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)..	1	6		
Carbonaceous shale	0	1		
Gray argillo-arenaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)	2	6		
COAL	0	6		
			7	2
Gray argillo-arenaceous shale, with *stigmariæ* leaves (*underclay*)			2	0
Gray arenaceous shale, with *stigmariæ* leaves (*underclay*)			6	0
Gray arenaceous shale and rough argillaceous sandstone			9	0
Greenish gray arenaceous shale			5	0
Gray sandstone			3	0
Red and green argillaceous shale, with *ironstone* balls..			7	0
Gray rough sandstone			17	0
Red argillaceous shale, with *ironstone* balls; thin beds of arenaceous shale and sandstone in the middle......			10	0
Red sandstone			1	0
Red argillaceous shale, with *ironstone* balls..........			1	0
Red sandstone			1	0
Red and green shale, with *ironstone* balls and some arenaceous beds			18	0
Gray sandstone			2	0
Gray arenaceous shale			4	0
Green and red shale			3	0
Gray sandstone			3	0
(From the upper part of the succeeding bed there arises an upright *sigillaria.*)				
Gray argillaceous shale			17	0
Gray argillaceous shale, with a layer of sandstone....			3	0
Gray sandstone			0	6
Greenish gray argillaceous shale			17	0
Gray sandstone			1	0

			Ft.	In.
Gray argillaceous shale, with *ironstone* balls and a few bands of arenaceous shale			17	0
6. *Carbonaceous shale*	1	0		
Bituminous limestone, with *shells*	0	10		
COAL	0	4		
			2	2
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)			2	0
Rough gray argillaceous sandstone, with the branches and leaves of *stigmariæ ficoides* (*underclay*)			7	0
(An upright stem penetrating the above bed springs from the one below.)				
Gray argillaceous shale, with *ironstone* nodules			1	0
Gray sandstone			1	0
Gray argillaceous shale, with *ironstone* nodules			2	0
Gray arenaceous shale			10	0
Gray sandstone			3	0
Gray argillaceous shale			3	0
Gray sandstone			2	0
7. COAL	0	10		
Carbonaceous shale	0	2		
COAL	0	10		
Carbonaceous shale	0	2		
COAL	2	0		
COAL and *Carbonaceous shale*	0	6		
			*4	6
Gray argillaceous shale, with *stigmariæ* (*underclay*)			6	0
Gray argillaceous shale, loaded with a multitude of *ironstone* balls			10	0
Gray argillaceous shale in beds of 1 to 3 feet, with sandstone and arenaceous shale in beds of 1 foot; *ironstone* nodules are very numerous in the whole			20	0
Gray argillaceous shale, with *ironstone* nodules			9	0

* Joggins "Main Seam."—*Editor*.

			Ft.	In.
Gray sandstone			3	0
Gray argillaceous shale, with *ironstone nodules*			10	0
Gray sandstone			1	0
Gray argillaceous shale			2	0
(From the succeeding bed springs an upright *sigillaria* of 1 foot in diameter; the lower part commences to spread.)				
Gray argillaceous shale, with *ironstone* balls and some sandstone			2	0
Gray argillaceous shale, with *ironstone* balls			5	0
8. COAL	0	2		
Gray argillaceous shale	0	4		
COAL	0	3		
Carbonaceous shale and *Coal*	1	3		
COAL	0	1		
Gray argillaceous shale, with *ironstone* balls and *stigmariæ* (*underclay*)	4	0		
COAL	1	0		
			7	1
Gray argillo-arenaceous shale, with *ironstone* balls in abundance and *stigmariæ ficoides* (*underclay*)			6	0
Gray rough crumbly sandstone			9	0
Dark gray shale, with *ironstone* balls			1	0
Gray arenaceous shale			3	0
Gray sandstone			3	0
Red argillaceous shale (chocolate coloured)			10	0
Gray sandstone			1	0
Red argillaceous shale as before			10	0
Gray rough sandstone			3	0
Red argillaceous shale, as before, in beds of 1 to 4 feet, with *ironstone* balls, and separated by beds of gray sandstone of 1 foot			20	0
Gray rough sandstone, in beds of 1 to 2 feet, alternating with beds of red or chocolate coloured shale of 1 foot			15	0

	Ft.	In.
Gray soft sandstone	1	0
Red shale	1	0
Gray rough sandstone	1	6
Gray arenaceous shale, with *stigmariæ* (*underclay*)	2	0
Gray crumbly arenaceous shale, with *ironstone* balls	6	0
Gray arenaceous shale	2	0
Gray crumbly sandstone	1	0
Gray argillaceous shale	0	10
Gray sandstone, with *stigmariæ* and upright *calamites* (*understone*)	1	6
Gray argillaceous shale, with *ironstone* balls	1	10
Gray rough crumbly sandstone	0	10
Gray argillaceous shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)	10	0
9. COAL and *Carbonaceous shale*	1	3
Greenish gray argillaceous shale, with *stigmariæ ficoides* (*underclay*)	12	0
Gray rough sandstone, with *stigmariæ* (*underclay*)	3	0
Red argillaceous shale, with *ironstone* balls	2	0
Reddish sandstone	2	0
Red or chocolate coloured argillaceous shale, with *ironstone* balls	5	0
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)	1	6
Red argillaceous shale and gray arenaceous shale	3	0
10. COAL and *Carbonaceous shale* . . . 0 2		
Carbonaceous shale . . . 0 6		
COAL . . . 0 4		
	1	0
Argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)	1	0
Measures concealed, probably underclay. Here occurs BELL'S BROOK	5	0
Red and green shale as before	9	0

	Ft.	In.
Gray sandstone	1	0
Red argillaceous shale and gray arenaceous shale	3	0
Red and green shale, as before	3	0
Gray arenaceous shale	2	0
Red and green shale, as before	7	0
Gray sandstone	3	0
Red and green shale, as before	3	0
Gray sandstone	1	0
Red or chocolate coloured argillaceous shale	2	0
Gray sandstone	1	0
Red and green shale, as before	5	0
Red or chocolate coloured argillaceous shale	1	0
Gray arenaceous shale	14	0
Gray sandstone, rough and uneven	12	0
(From the top of the succeeding bed spring several upright *calamites*, 3 of them in the distance of 2 feet, and 8 more—the whole 11, in the distance of 20 feet.)		
Gray crumbly argillaceous shale, like *underclay* but no *stigmariæ* visible	2	0
Greenish sandstone	0	6
Red or chocolate coloured argillaceous shale	3	0
11. COAL and *carbonaceous shale*	0	8
Gray argillaceous shale, with *stigmariæ ficoides* (*underclay*)	7	0
Gray rough sandstone and arenaceous shale, in alternate layers	12	0
Greenish gray sandstone	1	0
Gray argillaceous shale	1	0
Gray arenaceous shale	6	0
Strong gray arenaceous shale and rough sandstone	4	0
Gray argillaceous shale	6	0
12. COAL and *carbonaceous shale*	1	0
Gray argillaceous shale, witht *stigmariæ ficoides* and *ironstone* balls (*underclay*)	2	0

	Ft.	In.
Gray argillaceous sandstone, with *stigmariæ* (*understone*)	3	0
Dark gray argillaceous shale	8	0
13. COAL and *carbonaceous shale*	0	6
Gray argillaceous shale, witth *stigmariæ* and *ironstone* balls (*underclay*)	2	0
Gray argillaceous sandstone, with *stigmariæ* (*underclay*)	2	0
Red and green shale, as before	7	0
Gray argillaceous sandstone, with *stigmariæ* (*understone*)	1	0
Red and green argillaceous shale, with *stigmariæ ficoides* (*underclay*)	7	0
Gray sandstone and shale	1	0
Red or chocolate coloured and green argillaceous shale	3	0
Gray soft shaly sandstone	1	0
Measures concealed, but supposed to be soft	7	0
Greenish gray soft sandstone	4	0
Measures concealed, but supposed to be soft	2	0
Gray sandstone	4	0
Measures concealed, but supposed to be soft	3	0
Reddish green sandstone	3	0
Gray sandstone and shale	1	0
Red argillaceous shale	1	0
Green arenaceous shale	1	0
Gray sandstone	1	0
Gray argillaceous shale	6	0
Green and red shale	3	0
Gray sandstone, with a bed of argillaceous shale	2	0
Greenish gray argillaceous shale, with *ironstone* balls	17	0
Reddish green sandstone	1	0
(In this are upright *calamites*—3 of them in the space of 1 foot.)		
Gray argillaceous shale	2	0

					Ft.	In.
Gray rough sandstone					1	0
Gray argillaceous shale					2	0
Greenish gray or drab coloured sandstone; grindstones have been quarried from this, but they are too hard for the best quality. This constitutes COAL MINE POINT					30	0
Gray argillaceous shale, with balls of *ironstone*					3	0
Greenish gray sandstone					1	0
Gray argillaceous shale, with balls of *ironstone*					8	0
14. COAL	0	3				
Carbonaceous shale	0	2				
COAL	0	3				
			0	8		
Gray argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)			6	0		
Carbonaceous shale	0	4				
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)	1	0				
Carbonaceous shale	0	8				
COAL	0	2				
			2	2	8	10
Gray argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)					2	6
Greenish gray sandstone					2	0
Gray argillo-arenaceous shale, with bands of sandstone					2	0
(From the succeeding bed there spring up erect *calamites*, penetrating the above bed 2 feet; 2 of them are within 2 feet of one another, and there are 7 more in the space of 8 feet.)						
15. *Carbonaceous shale*			1	0		
COAL			0	4		
					1	4
Gray crumbly sandstone and shale, with *stigmariæ* (*underclay*)					2	0

	Ft.	In.
Gray crumbly sandstone, very like *underclay*, but no *stigmariæ* visible	12	0
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)	5	0
Greenish gray sandstone	2	0
Dark red shale, with *ironstone* balls	4	0
Greenish gray sandstone	5	0
Dark red shale	1	0
Greenish gray sandstone	3	0
Dark red or chocolate coloured argillaceous shale	6	0
Greenish gray sandstone, and red or chocolate coloured shale of an argillo-arenaceous character	12	0
Gray argillo-arenaceous shale, with *stigmariæ* and some beds of sandstone with *stigmariæ* leaves crossing them(*underclay*)	12	0
Gray crumbly sandstone, with beds of argillaceous shale, and *ironstone* balls, very like *underclay*, but no *stigmariæ* visible	25	0
16. COAL and *carbonaceous shale*	0	6
Gray argillo-arenaceous shale, witth *stigmariæ* (*underclay*)	3	9
Greenish gray sandstone	10	0
Gray argillaceous shale	1	0
Gray soft sandstone	1	0
Gray argillaceous shale	0	6
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)	4	0
Gray argillaceous shale	6	0
17. COAL and *carbonaceous shale*	0	3
Gray argillo-arenaceous shale, witht *stigmariæ* (*underclay*)	2	0
Gray argillaceous sandstone	18	0
Gray argillaceous shale	11	0
18. COAL	0	8

			Ft.	In.
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)			1	6
Gray soft flaggy sandstone			3	6
Gray argillaceous shale, with *stigmariæ*(*underclay*)			3	0
Gray arenaceous shale, with *stigmariæ* (*underclay*)			3	0
Gray argillo-arenaceous shale, witth *stigmariæ* (*underclay*)			4	0
Gray soft flaggy sandstone, with *stigmariæ* at the top (*understone*)			3	0
Fine gray argillo-arenaceous shale			4	0
Greenish gray sandstone			1	0
Dark gray argillaceous shale			6	0
19. *Carbonaceous shale*	4	0		
Bituminous limestone, with *shells* and *fish scales*	2	6		
Coal	0	1		
			6	7
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)			2	6
Greenish gray sandstone			6	0
Gray argillaceous shale			12	0
20. *Black bituminous shale*	1	0		
Black bituminous limestone, with *shells*	1	6		
Coal	0	6		
			3	0
Gray argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)			2	6
Greenish gray sandstone			4	0
Gray argillaceous shale			1	6
(From the top of the succeeding bed springs an upright *sigillaria* 10 inches in diameter; 2 feet, 6 inches of it are visible.)				
21. Coal and *carbonaceous shale*	0	3		
Gray argillaceous shale, with *stigmariæ* (*underclay*)	1	6		

			Ft.	In
Gray argillaceous sandstone, with *stigmariæ* (*underclay*)	7	0		
Gray argillaceous shale	4	0		
COAL	0	8		
			13	5
Gray argillaceous shale, witth *stigmariæ* (*underclay*)			2	0
Gray argillaceous sandstone, with *stigmariæ* (*underclay*)			3	0
Gray argillaceous shale			9	0
Greenish gray crumbly sandstone			1	0
Gray argillaceous shale			5	0
22. COAL and *carbonaceous shale*			0	2
Gray argillaceous shale, with *stigmariæ* (*underclay*)			1	0
Greenish gray agillaceous sandstone, with *stigmariæ* (*underclay*)			2	0
Greenish gray sandstone			3	0
(From the succeeding bed springs an upright *sigillaria* 4 inches in diameter; of it 5 feet are seen. On the beach there was a transverse slice of a *sigillaria* 1 foot 6 inches in diameter, with fragments of plants on the divisional surfaces.)				
Argillaceous shale			2	0
23. Carbonaceous shale, with some layers of argillaceous shale	4	0		
COAL and *carbonaceous shale*	0	4		
Bituminous limestone, with minute *shells* and *stigmariæ ficoides*	0	4		
COAL and *carbonaceous shale*	0	4		
			5	8
Gray argillo-arenaceous shale, witht *stigmariæ* (*underclay*)			1	0
Gray crumbly argillo-arenaceous shale, very like *underclay* in quality, but no *stigmariæ* visible			5	0

	Ft.	In.
Gray argillo-arenaceous shale, with *stigmariæ* (*under-*		
Gray sandstone	3	0
Gray crumbly argillo-arenaceous shale, or sandstone, with *stigmariæ* (*underclay*)	6	0

(From the top of the succeeding bed springs an upright *sigillaria.* Its roots spread out into the shale. It is coated with coal, and the material of the interior cast is not of uniform quality, being partly sandstone and partly shale. The shale occupies a transverse portion about 6 inches thick, and is rather less than half way up the stem, of which about 6 feet are visible, running into the underclay above. From the root of the plant, as if it had wound round or been pushed aside by the root, proceeds a *stigmaria* branch. It runs horizontally a short distance, and the turns up vertically. The leaves proceeding from the vertical portion, are not at right angles to the branch, but in part at least assume a vertical direction, and run parallel with it; those emanating from the groved side (in ordinary cases the under part or belly of the branch) taking a downward, and those from the back an upward course. The leaves issuing from the sides may be at right angles to the branch, and run horizontally into the bed, but being thus concealed they could not be traced. At first sight the stigmariæ branch had much the appearance of being a continuation of the root of the sigillaria, but close inspection shewed that the two, although touching, were distinct. The former rested on the latter nearly one-eighth of a circle, but being then suddenly cut off, it may when entire have wound much farther round, and the carbonaceous envelopes of the two plants were clearly discernible. See fig. 5 [of the original cuts.])

Gray argillaceous shale	10	0

			Ft.	In.
24. *Bituminous limestone,* with *shells* and *cone in cone*	1	0		
COAL and *carbonaceous shale*	0	1		
			1	1
Gray argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)			2	0
Gray argillaceous shale			3	0
25. COAL and *carbonaceous shale*			0	8
Gray argillaceous shale, with *stigmariæ* (*underclay*)			2	0
Greenish gray sandstone, with *stigmariæ* leaves (*underclay*)			6	0
Greenish gray sandstone			9	0
Greenish gray sandstone and shale			4	0
Gray argillaceous shale, with *ironstone* balls			2	0
Greenish gray sandstone, with some beds of arenaceous shale			20	0
Gray argillaceous shale			2	0
Greenish gray sandstone			35	0
Gray argillaceous shale			10	0
Gray sandstone			7	0
(From the succeeding bed springs an upright *sigillaria* 1 foot 6 inches in diameter; it penetrates through the sandstone.)				
Gray argillaceous shale			2	0
Greenish gray sandstone			10	0
Gray argillaceous shale			2	0
26. *Carbonaceous shale*			0	4
Gray argillaceous shale, with *stigmariæ* (*underclay*)			3	0
Gray crumbly sandstone, being probably argillaceous; it contains *stigmariæ* leaves (*underclay*)			8	0
Gray argillaceous shale			2	0
27. COAL			0	3
Gray argillo-arenaceous shale, with *stigmariæ* leaves (*underclay*)			5	0

					Ft.	In.
Greenish gray sandstone, with shale dividing the beds; in the lower part is an upright *calamite* which springs from the succeeding bed					4	0
Gray argillaceous and arenaceous shale, witht *ironstone* balls and a few beds of sandstone					14	0
Greenish gray sandstone in 3 beds, divided by argillo-arenaceous shale					12	0
Gray argillaceous shale					3	0
Gray argillaceous shale, with *ironstone* balls and one course of sandstone					13	0
Greenish gray sasdstone					4	0
Gray argillaceous shale, with *ironstone* nodules					3	0
28. *Bituminous limestone* and *carbonaceous shale* in alternate layers of 1 to 3 inches, with *plants, shells* and *fish scales*			6	0		
COAL and *carbonaceous shale* — not much coal	3	0				
COAL and *carbonaceous shale*—a good deal of coal	4	0				
			7	0		
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)			4	0		
Carbonaceous shale	1	0				
COAL	0	6				
			1	6		
					18	6
Gray rough sandstone, with *stigmariæ* leaves (*underclay*)					3	0
Greenish gray argillaceous shale, with *ironstone* balls.					6	0
Gray sandstone					6	0
Greenish gray argillaceous shale with nodules of *ironstone* disseminated through it					7	0
Gray argillo-arenaceous shale, with *ironstone* balls and small seams of *coal*					7	0

					Ft.	In.
(From the succeeding bed rises an upright *sigillaria*; the roots spread on the top of it; the diameter of the plant is a foot; only 1 foot of the length is visible.)						
29. COAL and *carbonaceous shale*; the coal being a small seam on the top of the carbonaceous shale			2	0		
Gray argillo-arenaceous shale, with *stigmariæ* and *ironstone* balls disseminated through it (*underclay*)			2	0		
COAL	1	8				
Carbonaceous shale	0	3				
COAL	0	11				
Carbonaceous shale	0	4				
COAL	0	10				
			4	0		
Gray argillo-arenaceous shale, with *stigmariæ* leaves crossing the bed (*underclay*)			8	0		
Carbonaceous shale, gray argillo-arenaceous shale, with *stigmariæ* and small seams of *coal*			6	0		
COAL and *carbonaceous shale*	0	6				
Gray argillaceous shale	0	6				
COAL	0	6				
			1	6		
Gray argillaceous shale (*underclay?*)			0	10		
Bituminous limestone, with *plants, shells* and *fish scales*			0	3		
					24	7
Gray argillo-arenaceous shale, witth *ironstone* nodules and *stigmariæ* leaves (*underclay*)					7	0
Gray arenaceous shale and sandstone; the sandstone exhibits some *stigmariæ* leaves crossing it, and in the shale are *ironstone* nodules (*underclay*)					20	0
(From the succeeding bed rises an upright fluted stem (*sigillaria*) 10 inches in diameter, of which 12 feet are visible; and 2 upright *calamites*.)						

					Ft.	In.
Gray argillaceous shale with *ironstone* balls					6	0
30. COAL			0	4		
Dark gray argillaceous shale (*underclay?*)			2	0		
COAL and *carbonaceous shale*			0	2		
COAL			0	3		
Carbonaceous shale			0	6		
COAL			0	1		
					3	4
Gray soft clay (*underclay*)					2	0
Gray argillo-arenaceous shale and sandstone; the shale contains balls of *ironstone* at the bottom; there are *stigmariæ* leaves visible towards the top; towards the lower part of the bed of sandstone there is an upright *calamite* of 2 inches diameter, of which 18 inches are visible					15	0
Gray sandstone, with impressions of prostrate *sigillariæ* underneath					2	0
31. COAL and *carbonaceous shale*			1	0		
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)			1	0		
Gray argillaceous shale with streaks *coal*	0	6				
COAL	0	2				
			0	8		
					2	8
Gray argillaceous shale, with *ironstone* balls and *stigmariæ* leaves (*underclay*)			9	0		
Bituminous limestone, with *stigmariæ, shells* and *fish scales*			0	2		
					9	2
Gray sandstone					1	0
Gray argillaceous shale, with *ironstone* balls					7	0
Gray sandstone					2	0
Gray argillaceous shale, with *ironstone* balls					4	0

			Ft.	In.
Gray sandstone			6	6
Gray argillaceous shale			4	0
32. COAL	0	8		
Carbonaceous shale	0	1		
COAL	0	8		
Carbonaceous shale	0	1		
COAL	0	4		
Carbonaceous shale	0	3		
COAL	0	1		
Carbonaceous shale	0	1		
COAL	0	1		
			2	4
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)			4	0
Greenish gray argillo-arenaceous sandstone, with *stigmariæ ficoides* (*underclay*)			1	0
Greenish gray argillo-arenaceuos shale, with *stigmariæ* (*underclay*)			4	0
Greenish gray sandstone, with *stigmariæ* (*underclay*)			4	0
Greenish argillaceous shale			6	0
Reddish sandstone, with dividing bands of red shale of 3 inches to 1 foot			20	0
Reddish sandstone. The bed is of irregular thickness, the bottom swelling out suddenly in many places. The bed holds carbonized plants			2	0
(From the top of the succeeding bed there springs an upright *sigillaria*. Two feet of the length is seen, but it is cut clean off at the top and at the bottom by the measures, which pass both without disturbance. See fig. 6 [of original cuts.])				
Red argillaceous shale			5	0
Reddish arenaceous shale, with thin bands of sandstone			3	0
Reddish and greenish sandstone			4	0
Red and green arenaceous shale with *ironstone balls*, some bands of sandstone			25	0

			Ft.	In.
Red and green sandstone			12	0
Reddish and greenish argillaceous shale, loaded with *ironstone* balls, and having bands of sandstone			10	0
Reddish and greenish sandstone			10	0
Red and green argillaceous shale, loaded with *ironstone* nodules			10	0
Red and green sandstone			5	0
Greenish gray argillaceous shale			15	0
Greenish gray sandstone			2	0
(From the succeeding bed there starts an upright *sigillaria* 4 inches in diameter; it is planted 2 feet in it, penetrates the sandstone above, being 4 feet in length altogether.)				
Greenish gray argillaceous shale			6	0
33. *Carbonaceous shale*	1	0		
COAL	0	1		
			1	1
Grenish gray argillaceous shale, with *stigmariæ* leaves (*underclay*)			4	0
Red and gray sandstone, with arenacous shale			7	0
Red argillaceous shale, with a band of sandstone			4	0
Red sandstone, with bands of red arenaceous shale			10	0
Red and green argillaceous shale			20	0
Reddish sandstone			1	0
Red and green argillaceous shale			3	0
Reddish sandstone in uneven layers, with reddish bands of arenaceous shale			18	0
Red and green argillaceous shale			18	0
Reddish sandstone			2	0
Red arenaceous shale			3	0
Red and green argillaceous shale			4	0
Reddish sandstone			1	0
Red and green arenaceous shale			4	0
Reddish sandstone			1	0

	Ft.	In.
Red and green arenaceous shale	7	0
Reddish sandstone	1	0
Red argillaceous shale	3	0
Red and green argillaceous shale, with bands of sandstone	25	0
Red sandstone	1	0
Red and green shale, with bands of sandstone	12	0
Red and green sandstone	4	0
Red and green argillaceous shale, with bands of reddish sandstone	15	0
Red and green sandstone and shale	3	0
Red or chocolate coloured shale, with large balls of red argillaceous *ironstone*	12	0
Red and green sandstone, separated by bands of red and green argillaceous shale of about 1 foot each	30	0
Red or chocolate coloured argillaceous shale, with some balls of red argillaceous *ironstone*	12	0
Reddish sandstone	4	0
Red argillaceous shale	1	6
Red sandstone	2	0
Red argillaceous shale	2	0
Reddish sandstone	1	0
Red argillaceous shale, with a band of sandstone	12	0
Gray sandstone with *ironstone* nodules and *stigmariæ* leaves (*underclay*)	10	0
(From the succeeding bed rises 2 upright *sigillariæ*. The roots of one of them spread out just on the top of the bed, and 2 feet of the plant are visible. The roots of the other spread out likewise, but they sink deeper into the shale by 2 feet, and the plant penetrates further into the superincumbent sandstone. See fig. 7 [of the original cuts.])		
Red and gray variegated shale, with small balls of *ironstone* and *stigmariæ* (*underclay*)	28	0

			Ft.	In.
Gray sandstone			2	0
Greenish shale, with *ironstone* balls and *stigmariæ ficoides* (*underclay*)			4	0
34. *Carbonaceous shale* and *coal*	0	2		
Greenish gray argillaceous shale, with *ironstone* balls and *stigmariæ* branches and leaves; one of the branches replaced by ironstone, is 8 feet long	4	0		
Carbonaceous shale	0	2		
			4	4
Gray argillo-arenaceous shale, with black streaks and *stigmariæ* (*underclay*)			3	0
Gray sandstone, with *stigmariæ* (*understone*)			0	10
Red and green argillaceous shale, with *stigmariæ* (*underclay*)			4	0
Gray crumbly sandstone			3	0
Gray argillo-arenaceous shale, with *stigmariæ* (*underclay*)			3	0
35. *Carbonaceous shale*			0	3
Red and green argillaceous shale, with *stigmariæ* leaves at the top (*underclay*)			6	0
Argillaceous *ironstone* in a bed			0	6
Red and green argillaceous shale			1	0
Gray sandstone, with *stigmariæ* leaves (*underclay*)			1	0
Greenish gray argillaceous shale, with dark bands; argillaceous iron ore nodules abound, and towards the top *stigmariæ* branches and leaves are visible (*underclay*)			28	0
Greenish gray crumbly sandstone			8	0
Gray argillaceous shale, with *ironstone* balls. In this there is visible an upright stem (*sigillaria*), 1 foot in diameter; the top only is visible, and it is at the top of the bed			12	0

			Ft.	In.
36. *Black bituminous limestone,* with branches and leaves of *stigmariæ* well marked and very minute *shells*	1	3		
Carbonaceous shale and streaks of *coal*	0	3		
	———		1	6
Red argillaceous shale, with *ironstone* (*underclay?*)			4	0
Gray argillo-arenaceous shale, with *stigmariæ* and *ironstone* balls (*underclay*)			6	0
Gray argillaceous shale, with *ironstone* balls			5	0
Gray arenaceous shale			2	0
Gray argillaceous shale			5	0
37. *Dark bituminous limestone,* with shells replaced by pyrites	0	3		
COAL and *carbonaceous shale*	0	10		
Gray argillaceous shale, *stigmariæ* (*underclay*)	1	6		
COAL	0	6		
Gray argillaceous shale, with *stigmariæ* (*underclay*)	1	0		
Dark bituminous limestone, with *stigmariæ* branches and leaves, and also *shells*	0	3		
Gray argillaceous shale	0	3		
COAL	1	0		
	———		5	7
Gray argillaceous shale of a crumbly character, with *ironstone* balls and *stigmariæ* (*underclay*)			6	0
Greenish gray rough sandstone			4	0
Dark gray argillaceous shale, with *ironstone* balls			7	0
Greenish gray sandstone			1	0
Red argillaceous shale			4	0
Greenish gray sandstone			2	0
Red argillaceous shale, with *ironstone* balls			8	0
Red and green sandstone, with bands of red argillaceous shale under 8 inches thick			6	0

			Ft.	In.
Red argillaceous shale, with bands of sandstone under 8 inches thick			20	0
Reddish sandstone, hard			1	0
Red argillaceous shale, with balls of *ironstone*			4	0
Reddish sandstone, hard			0	3
Green argillaceous shale			0	6
Greenish gray sandstone, with carbonized fragments of drift plants			1	0
Dark gray argillaceous shale, with a red band near the top			10	0
38. COAL	0	1		
Black bituminous limestone, with *shells* and *plants, stigmariæ* branches and leaves	0	6		
COAL	0	2		
			0	9
Red argillaceous shale, studded with *ironstone* balls; *stigmariæ* not visible (*underclay?*)			10	0
Reddish sandstone			2	0
Green arenaceous shale, with red argillaceous bands			15	0
Red and green sandstone			2	0
Red argillaceous shale			1	0
Green arenaceous shale			1	0
Red argillaceous shale			3	0
Green arenaceous shale			1	0
Red argillaceous shale			5	0
Gray bituminous limestone, with *minute shells*			0	6
Red argillaceous shale, with *ironstone* balls			11	0
Green and dark gray argillaceous shale, with *ironstone* balls			14	0
Red and green argillaceous shale, with *ironstone* balls; in this are some dark bands of shale			25	0
Greenish gray sandstone, with a confused mass of carbonized drift plants			10	0
Greenish gray sandstone			2	6
Red argillaceous shale, with a band of sandstone			2	0

			Ft.	In.
Gray and black shale			3	0
Carbonaceous shale			1	0
Red and green argillaceous shale, studded with *ironstone* balls; no *stigmariæ* visible (*underclay?*)			15	0
39. Coal	0	0½		
Gray argillaceous shale, with *stigmariæ*	0	6		
Dark gray limestone, with *stigmariæ* branches and leaves, and minute shells	0	4		
			0	10½
Red and green argillaceous shale, with *stigmariæ* leaves (*underclay*)			1	6
Red and green sandstone			1	0
Red argillaceous shale, with some green and gray bands; the whole containing thin bands of sandstone			18	0
Greenish gray sandstone			8	0
Dark red and green argillaceous shale, studded with *ironstone* balls			15	0
Gray hard argillaceous sandstone			1	0
Dark gray argillaceous shale, with *ironstone* balls in considerable number, with some red argillaceous beds			20	0
40. *Black bituminous limestone*, with *shells.*	0	1½		
Carbonaceous shale	0	0½		
Black bituminous limestone, with *shells*	0	1		
Gray argillaceous shale	0	2		
Black bituminous limestone, with *shells*	0	2		
Gray argillaceous shale, with *ironstone* balls (*underclay?*)	1	0		
Coal	0	1		
Carbonaceous shale, with thin seams of *coal*	0	3		
Gray argillo-arenaceous shale, with *stigmariæ ficoides* (*underclay*)	1	0		
Black bituminous limestone, with *shells* and *stigmariæ*	0	6		
Carbonaceous shale and thin *laminæ* of *coal*	0	2		
			3	7

			Ft.	In.
Green argillaceous shale, with many coarse nodules of clay *ironstone*, all small, and impressions of *stigmariæ* leaves crossing the bed (*underclay*)........			5	0
41. *Black calcareo-bituminous shale* with *shells*	0	8		
Black calcareo-bituminous shale, more calcareous, with *shells*	0	2		
Black calcareo-bituminous shale, less calcareous, with *shells*	1	0		
Carbonaceous shale, with *laminæ* of *coal*..	1	6		
Gray argillaceous shale, with *stigmariæ* (*underclay*)	3	0		
Carbonaceous shale	0	1		
			6	5
Gray argillaceous shale, with *stigmariæ* (*underclay*)			2	0
Greenish gray argillo-arenaceous shale, in alternate hard and soft layers, with *stigmariæ* leaves (*underclay*)			2	6
Greenish gray sandstone			2	0
Dark gray argillaceous shale, studded with *ironstone* nodules			4	0
42. *Carbonaceous shale*	0	7		
Black bituminous limestone, with *shells* replaced by pyrites	0	2		
COAL	0	3		
Carbonaceous shale	1	0		
COAL	1	0		
Gray argillaceous shale, with *stigmariæ* (*underclay*)	1	0		
COAL	0	2		
			4	2
Dark gray argillaceous shale, with *stigmariæ* (*underclay*)			5	0
Red argillaceous shale, with some green bands, and studded with *ironstone* balls			25	0
Reddish sandstone			1	0

			Ft.	In
Red argillaceous shale, with *stigmariæ* (*underclay*) . .			4	0
43. *Carbonaceous shale*			0	1
Red shale, with *stigmariæ* (*underclay*)	0	3		
Gray sandstone, very hard, (*ganister,* as the Lancashire miners call it), with *stigmariæ*	0	8		
Red argillaceous shale, with *stigmariæ* (*underclay*)	3	0		
Gray sandstone, very hard, with *stigmariæ* (*ganister* or *understone*)	0	10		
Gray argillaceous shale, with *stigmariæ* (*underclay*)	0	10		
Gray sandstone, very hard, with *stigmariæ* (*understone*)	1	0		
Gray sandstone, very hard, with *stigmariæ* leaves running across the bed, (*ganister* or *understone*)	2	0		
			8	7
Red argillaceous shale, green at the bottom			15	0
Gray arenaceous and argillaceous shale, with greenish gray sandstone containing prostrate carbonized plants			12	0
(Into this bed penetrate several upright *calamites* which start from the one subjacent, on the top of which one 3 inches in diameter is seen to spread its roots, and 21 more are visible along the face of the bank in the space of 20 yards; their diameters vary from ½ inch to 4 inches.)				
Dark gray argillaceous shale			2	0
Gray sandstone			1	0
Dark gray argillaceous shale			15	0
Gray sandstone			0	4
Dark gray argillaceous shale, with *ironstone* balls and bands of sandstone			4	0
Dark gray argillaceous shale, with *ironstone* balls. . . .			5	0

			Ft.	In.
44. *Carbonaceous shale*	1	6		
Dark gray argillaceous shale	2	0		
Carbonaceous shale, with *ironstone* balls...	0	4		
Dark gray argillaceous shale, with *ironstone* balls	6	0		
Black bituminous limestone, with *shells*....	0	1½		
Dark green argillaceous shale	0	1½		
COAL	0	0½		
Black bituminous limestone with plants and minute *shells*	0	0½		
COAL	0	5		
Black bituminous limestone, with *stigmariæ* and other plants	0	2		
COAL	0	1		
Black bituminous limestone, with *stigmariæ* branches and leaves, and fragments of other plants	0	2		
COAL	0	0½		
			11	0½
Gray crumbly argillo-arenaceous shale, with indistinct *stigmariæ leaves* (*underclay*)			3	0
Red and green crumbly argillaceous shale (*underclay*)			10	0
Red and green sandstone			5	0
Red or chocolate coloured argillaceous shale			1	6
Reddish sandstone			1	0
Red or chocolate coloured argillaceous shale			1	0
Greenish gray sandstone			9	0
Red argillaceous shale, with thin green beds and some patches of sandstone			40	0
Red shale, with a considerable number of small beds of sandstone			6	0
Greenish gray sandstone, with upright *calamites* about 2 inches in diameter; some of them are traceable for 4 feet in the upper part of the bed; 6 of them are visible; the top of the bed is reddish in colour......			10	0

			Ft.	In.
Red argillaceous shale, studded with *ironstone* balls..			10	0
Gray hard argillo-arenaceous shale, with *stigmariæ* (*underclay*)			1	0
Red argillaceous shale			1	0
45. *Carbonaceous shale*	0	10		
COALY matter	0	0½		
Gray hard argillo-arenaceous stone, with *stigmariæ* (*underclay*)	2	0		
COALY matter	0	0½		
Green argillaceous shale, with *stigmariæ* (*underclay*)	7	0		
COAL	0	3		
			10	2
Greenish gray arenaceous shale with *stigmariæ* (*underclay*)	3	0		
Red arenaceous and argillaceous shale, with sandstone	2	0		
Red sandstone of a soft quality	0	6		
	2539	1		

RECAPITULATION.

COAL in 45 seams	37	9½		
Carbonaceous shale associated with the above coal seams, and in one instance without coal	36	4		
Gray argillaceous shale interstratified with the coal seams in 8 cases, in two of which the shale is 1 foot and upwards thick without exhibiting any remains of stigmariæ	4	4½		
Black and grey bituminous limestone touching the coal and carbonaceous shale, often interstratified and containing the remains of fishes, shells and occasionally stigmariæ. In one instance the limestone has no coal with it; in 16 cases it is associted with the coal seams	23	3		
			101	9

Underclay or understone, being beds of various materials, immediately subjacent to the seams of coal and carbonaceous shale and bituminous limestone, and invariably penetrated by the recumbent branches or radiating leaves of the stigmariæ ficoides. Every one of the seams of coal and carbonaceous shale rests upon a stigmaria bed, with the exception of one instance, where 4 feet of gray argillaceous shale, destitute of the plant, is interposed between the stigmariæ bed and the coal, and one instance where the stigmariæ are doubtful. There are twelve instances of stigmariæ beds without superincumbent coal. The material constituting the stigmariæ beds is as follows:

					Ft.	In.
Ganister, a hard silicious stone					4	6
Sandstone—						
Gray and crumbly, sometimes a doubtful fireclay			72	10		
Greenish gray			4	0		
					76	10
Arenaceous shale, fit for fire clay—						
Gray			189	0		
Greenish gray			25	6		
Red			6	0		
					220	6
Argillaceous shale, sometimes fit for fireclay—						
Gray	99	4				
Greenish gray	28	0				
Green	12	10				
Red and green	45	0				
Red	17	3				
			202	5		
					504	3

					Ft.	In.
Sandstone—						
Gray in colour, and much of it of a crumbly nature, resembling the quality in which the remains of stigmariæ are found			259	2		
Greenish			4	6		
Greenish gray or drab coloured, some of it fit for grindstones, and patches of it containing carbonized drift plants			232	6		
Red and green, less durable in quality than the drab coloured stone.			69	0		
Reddish, similar to the preceding in durability			67	3		
Red or chocolate coloured, easily yielding to the influence of weather			15	6		
					647	11
Shale—Arenaceous—						
Gray	91	0				
Gray, with ironstone balls	13	0				
			104	0		
Greenish gray			5	0		
Green			18	6		
Reddish			15	8		
Red and green	42	0				
Red and green, with iron stone balls	4	0				
			46	0		
					189	2
Shale—Argillaceous—						
Gray	224	8				
Gray, with ironstone balls	199	4				
			424	0		

							Ft.	In.
Greenish gray	32	0						
Greenish gray, with ironstone balls	17	0						
			49	0				
Green			38	6				
Red and green	153	6						
Red and green, with ironstone balls	118	6						
			272	0				
Red or chocolate coloured	230	6						
Red or chocolate coloured, ironstone balls	82	0						
			312	6				
					1096	0		
							2539	1

(Among the organic remains visible, are to be enumerated 15 upright sigillariæ and 56 upright calamites.)

5

Red argillaceous shale, with *ironstone* balls	6	0
Red arenaceous shale	2	0
Red argillaceous shale, with beds of arenaceous shale	16	0
Red sandstone	1	0
Red argillaceous shale	22	0
Red sandstone	1	0
Red argillaceous shale	7	0
Red argillaceous shale, with a bed of sandstone	38	0
Red sandstone	1	0
Red argillaceous shale, with a bed of red sandstone	50	0
Measures concealed, but supposed to be red shale and sandstone	19	0
Red sandstone	1	0

	Ft.	In.
Measures concealed, (red shale and sandstone?)	33	0
Greenish gray soft sandstone, with fragments of plants carbonized	3	0
Measures concealed	32	0
Measures concealed, (red shale and sandstone?), a bed of sandstone at the top	39	0
Greenish gray sandstone	3	0
Measures concealed, (red shale and sandstone?)	19	0
Measures concealed, (red shale and sandstone?) a bed of red sandstone at the top	50	0
Red sandstone	30	0
Measures concealed, (red shale?)	3	0
Red sandstone	1	0
Measures concealed, (red shale and sandstone?)	40	0
Red shale, with some red sandstone	33	0
Measures concealed, (red shale and sandstone?)	30	0
Reddish gray sandstone	5	0
Measures concealed	3	0
Red and gray sandstone of a soft quality	32	0
Red arenaceous shale and sandstone	6	0
Reddish gray sandstone of a soft quality	6	0
Red argillaceous and arenaceous shale	20	0
Red sandstone	2	0
Red argillaceous shale	25	0
Red sandstone	2	0
Red argillaceous and arenaceous shale	12	0
Red sandstone and shale	8	0
Red shale and sandstone	54	0
Measures concealed, (red shale?)	12	0
Measures concealed, (red sandstone and shale?)	3	0
Measures concealed, (red shale?)	28	0
Red shale and sandstone	11	0
Red sandstone	2	0
Measures concealed, but supposed to be red shale	6	0

	Ft.	In.
Measures concealed, but supposed to be red sandstone.	12	0
Measures concealed, but supposed to be red shale.....	138	0
Red arenaceous shale, with some beds of red sandstone.	12	0
Red arenaceous shale, with some beds of red sandstone.	43	0
Red sandstone	17	0
Red arenaceous shale	14	0
Measures concealed	30	0
Red sandstone	6	0
Measures concealed, but supposed to be red shale and sandstone	6	0
Reddish gray sandstone	9	0
Measures concealed, but supposed to be red shale and sandstone	5	0
Red sandstone	2	0
Measures concealed, but supposed to be red sandstone.	44	0
Red shale and sandstone	12	0
Measures concealed, but supposed to be red shale and sandstone	33	0
Red argillaceous and arenaceous shale, with some beds of red sandstone	132	0
Red sandstone	3	0
Red arenaceous shale and sandstone	17	0
Greenish gray sandstone, with patches of concretionary limestone	13	0
Red argillaceous and arenaceous shale	51	0
Reddish sandstone	17	0
Measures concealed	37	0
Reddish green sandstone	24	0
Measures concealed	17	0
Reddish gray sandstone	18	0
Measures concealed	19	0
Reddish sandstone	5	0
Measures concealed, probably red shale	73	0
Reddish gray sandstone, soft, with fragments of plants carbonized	22	0

	Ft.	In.
Measures concealed, but supposed to be red shale	37	0
Red and green sandstone, with probably some patches of concretionary limestone	37	0
Red argillaceous and arenaceous shale, with bands of sandstone	38	0
Red sandstone	2	0
Red argillaceous and arenaceous shale, with bands of sandstone	18	0
Red sandstone	3	0
Red argillaceous shale	1	0
Greenish gray sandstone	9	0
Green argillaceous shale	2	0
Greenish gray sandstone	5	0
Red argillaceous and arenaceous shale, with some beds of red sandstone	50	0
Greenish gray sandstone	7	0
Greenish gray sandstone, with concretions of limestone giving it much the appearance of a conglomerate ...	1	0
Red argillaceous shale	1	0
Red and green sandstone	6	0
Green shale	2	0
Greenish gray sandstone	1	0
Grenish gray sandstone, with many calcareous concretions, giving it much the appearance of a conglomerate	6	0
Red arenaceous and argillaceous shale, with some beds of sandstone	17	0
Red argillaceous shale and sandstone	16	0
Red arenaceous and argillaceous shale, with some sandstone	8	0
Red argillaceous shale	6	0
Red arenaceous shale, with some bands of sandstone..	6	0
Red sandstone	12	0
Red argillaceous shale	1	0
Red sandstone	1	0

	Ft.	In.
Red argillaceous and arenaceous shale, with a two feet bed of sandstone	29	0
Red sandstone, thinning off and replaced by red shale	5	0
Red argillaceous shale	5	0
Red sandstone	2	0
Red argillaceous shale	3	0
Red arenaceous shale	1	0
Red argillaceous shale	3	0
Red arenaceous shale and sandstone	3	0
Red argillaceous shale	22	0
Reddish sandstone	7	0
Reddish sandstone with a one foot bed, having calcareous concretionary nodules, and resembling a conglomerate, with carbonized plants on the top	16	0
Red argillaceous and arenaceous shale	20	0
Red sandstone	8	0
Red arenaceous shale and argillaceous shale	12	0
Red sandstone and shale, half of each	12	0
Red argillaceous shale	5	0
Red arenaceous shale	1	0
Red sandstone	5	0
Red arenaceous shale	7	0
Red sandstone	3	0
Red arenaceous shale	3	0
Red sandstone	2	0
Red argillaceous shale	8	0
Red sandstone	1	0
Red arenaceous shale	5	0
Red sandstone	1	0
Red argillaceous shale	6	0
Red sandstone	1	0
Red argillaceous shale	28	0
Red arenaceous shale	2	0
Red argillaceous shale	15	0
	2082	0

RECAPITULATION.

					Ft.	In.
Sandstone—						
Greenish gray, with occasional drift plants carbonized	28	0				
Greenish gray, with concretionary limestone, having the aspect of conglomerate	20	0				
			48	0		
Reddish gray, with occasional drift plants carbonized	104	0				
Reddish gray, with concretionary limestone	16	0				
			120	0		
Shale—						
Red argillaceous	640	0				
Red arenaceous	230	0				
			870	0		
Green argillaceous			4	0		
					874	0
Measures not well exposed, but probably composed of red shale and sandstone					740	0
					2082	0

6

Greenish gray or drab coloured sandstone, fit for grindstones of good quality, which are extensively quarried from it. This is called the South Reef	50	0
Red argillaceous shale	14	0
Red sandstone	20	0
Measures concealed, probably red shale	2	0
Red sandstone	3	0
Red sandstone, with probably red shale on the top	7	0

	Ft.	In.
Measures concealed, but said to be red argillaceous and arenaceous shale, with occasional beds of red sandstone	103	0
Dark gray argillaceous shale, with a small quantity of fine grit in it. This would be called a fine *bluestone* in some parts of South Wales. At the Joggins, there is usually a bed of it above a good grindstone reef	4	0
Greenish gray or drab coloured sandstone, fit for grindstones of the very best quality. The whole reef has been quarried away up to the bank	36	0
Greenish gray sandstone, fit for grindstones of good quality. This has been much quarried	17	0
Greenish gray sandstone, fit for grindstones. This has been very much quarried	7	0
Greenish gray sandstone, fit for grindstones. This and the preceding greenish gray sandstones constitute what is called the NORTH REEF	9	0
Red and green argillaceous shale	18	0
Red sandstone of a soft quality	6	0
Red argillaceous shale	14	0
Red argillaceous and arenaceous shale, with 6 bands of red sandstone	27	0
Greenish gray sandstone	7	0
Red argillaceous shale	6	0
Red sandstone	4	0
Red arenaceous shale	4	0
Red argillaceous and arenaceous shale	10	0
Red argillaceous and arenaceous shale and red sandstone, in alternating beds	12	0
Red argillaceous shale, with 2 small beds of red sandstone	21	0
Red sandstone, with bands of red argillaceous shale	9	0
Red arenaceous shale, with bands of red sandstone	6	0
Red sandstone	1	0

			Ft.	In.
Red argillo-arenaceous shale, with thin bands of red arenaceous shale and red sandstone			30	0
Black calcareous bed, no shells visible			0	1
Red and green variegated argillaceous shale			6	0
Green arenaceous shale			1	0
Red arenaceous and argillaceous shale, in alternating beds			4	0
Red argillaceous shale			6	0
Reddish gray sandstone			6	0
Red argillaceous and arenaceous shale			10	0
Red and green variegated shale and sandstone			15	0
Red and green argillaceous shale			4	0
Red and green variegated sandstone			2	0
Red argillaceous shale			12	0
Red and green calcareous band			0	6
Green arenaceous shale, mixed in patches with red arenaceous shale			9	0
Red arenaceous shale of a crumbly character			12	0
Dark gray argillaceous shale, with *ironstone* balls			5	0
1. *Calcareous* shale	1	0		
Dark gray argillaceous shale	3	0		
COALY clay	0	2		
			4	2
Reddish and dark gray argillaceous and arenaceous shale, crossed by *stigmariæ* leaves (*underclay*)			6	0
Gray argillaceous shale			2	0
Dark gray argillo-arenaceous shale, of a fine smooth quality (*bluestone*)			7	0
Greenish gray or drab coloured sandstone, fit for grindstones			10	0
Gray arenaceous shale of a fine quality, in even beds			8	0
Dark gray argillo-arenaceous shale, of a fine smooth quality, such as usually covers grindstone beds			3	0

	Ft.	In.
Greenish gray sandstone, fit for grindstones. The top part contains large spherical concretions of harder sandstone, with a rusty exterior, and concentric variations of colour. This constitutes BACON LEDGE	54	0
Greenish gray sandstone, with a vast number of drift plants with a coating of coal. It holds also patches of limestone concretions, which have much the aspect of a conglomerate	10	0
Dirty green calcareous concretionary bed. This has so much the appearance of a conglomerate bed with limestone pebbles, that there is some doubt whether it be not so. It is a very irregular bed and holds carbonized plants	4	0
Reddish green argillo-arenaceous shale	1	0
Greenish arenaceous shale of a hard quality, probably fireclay, crossed by *stigmariæ* leaves (*underclay*)...	8	0
Red and green variegated argillaceous shale, with 2 feet of sandstone	8	0
Red arenaceous shale with green spots	5	0
Green arenaceous shale	1	0
Red arenaceous shale	1	0
Green arenaceous shale	1	0
Red argillaceous shale	2	0
Red and green arenaceous shale	2	0
Red argillaceous shale	1	0
Greenish gray arenaceous shale	3	0
Red and green arenaceous shale	2	0
Red argillaceous shale	3	0
Greenish gray arenaceous shale	4	0
Green clay	0	1
Red argillaceous shale	6	0
Reddish sandstone	1	0
Red argillaceous shale	5	0
Gray argillaceous shale	2	0

			Ft.	In.
2. COALY clay, probably coal further in the bank			0	1
Red and green argillo-arenaceous shale of a soft quality, crossed by *stigmariæ* leaves (*underclay*)			3	0
Red and green crumbly argillo-arenaceous shale, rather harder than the preceding, crossed by *stigmariæ* leaves (*underclay*)			6	0
Reddish sandstone, no *stigmariæ* visible			0	6
Red crumbly argillo-arenaceous shale, with *stigmariæ* (*underclay*)			2	0
Red argillo-arenaceous shale of a tough crumbly nature, with *stigmariæ* strongly marked (*underclay*)			2	0
Red argillaceous shale, with thin green bands and nodules of *ironstone*, a tough, crumbly mass			6	0
3. *Carbonaceous shale*	0	1		
Greenish argillaceous shale	0	6		
Carbonaceous shale	0	1		
Greenish argillaceous shale	2	6		
Carbonaceous shale	0	3		
Greenish argillaceous shale in thin leaves ..	0	1		
Coaly matter and *carbonaceous shale*	0	3		
			3	9
Green argillo-arenaceous shale of a soft quality, crossed by *stigmariæ* leaves (*underclay*)			3	0
Gray argillo-arenaceous shale, rather harder than the preceding, with *stigmariæ* leaves and many nodules of *ironstone* at the top where the bed is more arenaceous (*underclay*)			4	0
Gray sandstone, with *stigmariæ* leaves (*underclay*)..			1	0
Green argillo-arenaceous shale of a rather soft quality, with *stigmariæ* leaves (*underclay*)			4	0
4. COAL and *carbonaceous shale*			0	3
Green argillo-arenaceous shale, with *stigmariæ* leaves (*underclay*)			2	0
Red and green tough crumbly arenaceous shale, with *stigmariæ* branches and leaves (*underclay*)			2	0

	Ft.	In.
Red and green tough crumbly claystone, with balls of *argillaceous iron ore, stigmariæ* leaves crossing the bed (*underclay*)	2	0
Gray rough sandstone and tough crumbly red and green arenaceous shale; one *stigmariæ* branch visible without leaves, but leaves exist in other parts of the bed (*underclay*)	4	0
Red and green tough crumbly clay, some very like *underclay,* but no *stigmariæ* leaves visible	2	0
Dark gray argillaceous shale, no *stigmariæ* visible, but the mass tough and crumbly	1	0
Reddish argillo-arenaceous shale, with *stigmariæ* branches and leaves (*underclay*)	2	0
Red sandstone with green spots	3	0
Red and green variegated sandstone, the green in spots	3	0
Gray argillaceous shale	3	0
5. COALY matter	0	0⅛
Greenish arenaceous shale, with *stigmariæ* branches and leaves, the recumbent branches crossing one another and running in all directions (*underclay*)	8	0
Green sandstone	2	0
(From the succeeding bed there starts an upright *sigillaria* about 1 foot in diameter, only 2 feet of the length are visible.)		
6. *Carbonaceous shale*	0	3
Gray argillo-arenaceous shale, with *stigmariæ* leaves (*underclay*)	6	0
Greenish gray sandstone, with *stigmaræ* leaves (*underclay*)	4	0
Greenish gray sandstone, with *stigmariæ* branches and leaves (*underclay*)	2	0
Red argillo-arenaceous shale, with *stigmariæ* leaves (*underclay*)	3	0

	Ft	In.
(In these 15 feet of underclay there is a beautiful exhibition of stigmariæ. They are not very abundant, that is to say, in such profuse confusion as usual, but each plant is very distinct. One branch floats along just beneath the surface of the 2 feet bed mentioned, and 24 feet of its length are finely exposed without interruption. The leaves radiate from it distinctly, and individual leaves can be followed down 5 feet, crossing both the hard and the soft parts of the deposit continuously, and others can be traced 2 feet upwards. Where the branch enters a projecting part of the bed, its measurement is 2 inches vertically by 3 inches horizontally, and where the other extremity is lost beneath the beach the measurement is about the same, so that I could not come to any conclusion as to the direction in which the branch issues from the stem, if it has one. See fig. 8 [of the original cuts.])		
Greenish gray or drab sandstone in irregular beds ...	70	0
Greenish gray sandstone, with a vast quantity of drift plants lying in confusion and coated with coal. In one of the beds there appears a bundle of no less 10 plants squeezed together side by side, as represented in fig. 8 [of the original cuts.] Each has a core of sandstone surrounded by a good thick coating of crystallized coal. They run through and through a projecting ledge of 10 feet (see fig. 9 [of the original cuts]), and lie rather oblique to the plane of the bed, but conformably with its elementary layers....	30	0
Greenish gray sandstone, with some spherical concretions of a harder quality, with a rusty exterior	50	0
Greenish gray sandstone	22	0
Dark gray argillaceous shale	0	6

			Ft.	In.
Greenish gray arenaceous shale, with some fibrous impressions like *stigmariæ* leaves crossing the bed (*underclay*)			2	0
Red argillaceous shale			0	6
Greenish gray arenaceous shale			0	6
Red argillaceous shale			2	0
Green arenaceous shale			2	0
Greenish gray sandstone, with spherical concretions			4	0
Greenish gray sandstone and shale			5	0
Greenish gray sandstone			1	0
Gray argillaceous shale			0	10
Gray rough crumbly sandstone			5	0
Gray calcareous sandstone			0	6
7. *Bituminous limestone*	0	3		
Gray argillaceous shale	3	0		
Gray calcareous bed	0	2		
Carbonaceous shale	0	6		
Bituminous limestone, with *shells* and *fish scales; fish jaws* occur	0	3		
Carbonaceous shale, being a mass of platted plants, apparently grasses	1	0		
COAL	0	1		
			5	3
Gray argillo- arenaceous shale, with *stigmariæ* (*underclay*)			5	0
Gray arenaceous shale			5	0
Greenish gray sandstone			7	0
Gray arenaceous shale			2	0
Greenish gray sandstone			1	0
Gray arenaceous shale			2	6
Greenish gray sandstone			0	6
Gray soft arenaceous shale			4	0
Greenish gray soft flaggy sandstone, with ripple mark			10	0
Greenish gray soft flaggy sandstone			4	0

	Ft	In.
Gray arenaceous shale	4	0
Greenish gray sandstone	4	0
Greenish gray soft flaggy sandstone, scarcely standing the weather	14	0
Greenish gray sandstone, in regular beds	27	0
Measures concealed, but no doubt soft, probably argillaceous shale, with a mixture of arenaceous	100	0
Gray arenaceous shale	8	0
Gray argillaceous shale	6	0
Greenish gray sandstone, fit for grindstones. This has been quarried to a considerable extent, and worked deep into the bank. It is the best quarry of this reef, but the stone is rather too hard	10	0
Greenish gray sandstone of grindstone quality	6	0
Greenish gray sandstone. This has been worked for grindstones, but the quality is rather hard	14	0
Greenish gray sandstone fit for grindstones, but rather too hard. This bed exhibits spherical concretions in some parts, some of which are 6 to 8 inches in diameter. These grindstone beds constitute what is called the UPPER COVE REEF	18	0
Greenish gray sandstone	34	0
Greenish gray sandstone in flaggy beds	49	0
Greenish gray sandstone of a stronger quality	8	0
Greenish gray sandstone in flaggy beds	15	0
Greenish gray sandstone	34	0
Greenish gray argillaceous shale	9	0
Greenish gray sandstone. This constitutes BOSS POINT	42	0
Greenish gray sandstone	6	0
Greenish gray sandstone, with drift plants coated with coal	12	0
Greenish gray sandstone in regular beds	28	0
Greenish gray sandstone, with carbonized drift plants	7	0

	Ft.	In.
Greenish gray sandstone in more regular beds	9	0
Greenish gray sandstone, with drift carbonized plants.	9	0
Greenish gray sandstone, pervaded by a tangled mass of carbonized drift plants	6	0
Greenish gray sandstone	12	0
Gray argillaceous shale	1	0
8. COAL occurring in patches	0	$0\frac{1}{2}$
Gray argillo-arenaceous shale, with the aspect of fire-clay, with *stigmariæ* branches and leaves very distinctly exhibited (*underclay*)	7	0
Gray arenaceous shale	3	0
Greenish gray argillaceous shale, with nodules of *clay ironstone* disseminated in considerable quantity....	5	0
Gray argillaceous shale	10	0
Greenish gray sandstone	18	0
Greenish gray sandstone, with carbonized drift plants in confusion	7	0
Greenish gray sandstone	10	0
Greenish gray sandstone, with carbonized drift plants in confusion	4	0
Greenish gray sandstone	7	0
Greenish gray sandstone, with carbonized drift plants in confusion	3	0
Greenish gray sandstone	15	0
Greenish gray sandstone, with spherical concretions of a harder qualit y..........................	7	0
Greenish gray sandstone, with a few carbonized drift plants	18	0
Gray arenaceous shale	2	0
Greenish gray sandstone	12	0
Greenish gray sandstone, with a confused multitude of carbonized drift plants	4	0
Greenish gray sandstone, with a few carbonized drift plants	21	0

	Ft.	In.
Greenish sandstone, with calcareous concretionary nodules, having much the aspect of a conglomerate, with limestone pebbles. The bed is very uneven ...	1	0
Greenish gray sandstone, with carbonized drift plants	13	0
Greenish gray sandstone, in even beds	12	0
Greenish gray sandstone, with carbonized drift plants	10	0
Greenish gray sandstone	51	0
Gray argillaceous and red argillaceous shale	23	0
Greenish gray sandstone, fit for grindstones, but rather hard. This constitutes Boss Quarry	10	0
Greenish gray sandstone	25	0
Greenish gray sandstone, with carbonized drift plants.	6	0
Greenish gray sandstone	24	0
Greenish gray sandstone, with nodules of *clay ironstone,* casts of *calamites* and other plants..........	1	0
Gray arenaceous shale	4	0
Red argillaceous shale	6	0
Greenish gray arenaceous shale	3	0
Gray argillaceous shale	12	0
Gray arenaceous shale	3	0
Yellow sandstone, very soft and yielding to the weather	4	0
Gray argillaceous shale	7	0
Yellow sandstone, very soft and yielding to the weather	21	0
Greenish gray sandstone in even beds	4	0
Gray arenaceous shale	4	0
Greenish gray sandstone, fit for grindstones	18	0
Gray arenaceous shale	4	0
Greenish gray sandstone	7	0
Greenish gray sandstone, with carbonized drift plants	9	0
Greenish gray sandstone in regular beds	21	0
Gray arenaceous shale and sandstone...............	1	0
Greenish gray sandstone	13	0
Gray argillaceous shale	1	0
Greenish gray sandstone	27	0

	Ft.	In
Gray argillaceous shale	6	0
Greenish gray sandstone	30	0
Greenish bed with concretions of limestone very much resembling a calcareous conglomerate	5	0
Gray argillaceous shale	5	0
Greenish bed of calcareous concretions, very much resembling a calcareous conglomerate	9	0
Gray arenaceous shale, with some bands of sandstone	23	0
Greenish gray sandstone	64	0
Greenish gray sandstone	27	0
(Here there appears to be a small fault. It does not disturb the strike, but the dislocation, if there is any, is not ascertained. I do not think it can be many yards.)		
Greenish gray sandstone	34	0
Greenish gray sandstone, with many carbonized drift plants	14	0
Greenish gray sandstone, more regular in the beds	16	0
Greenish gray sandstone, with some carbonized drift plants	18	0
Greenish gray sandstone, with many carbonized drift plants in great confusion	9	0
Greenish bed, with calcareous concretions, having much the aspect of a calcareous conglomerate	1	0
Greenish gray sandstone, with many prostrate carbonized drift plants	9	0
Greenish gray sandstone, a solid mass without divisions	21	0
Greenish gray sandstone, with a vast and confused collection of carbonized drift plants, one lying prostrate measured 25 feet in length and about 1 foot in diameter, at the small end	19	0
Greenish gray sandstone more regular	117	0
Greenish gray sandstone with carbonized drift plants, and holding small patches of concretionary nodulous limestone very like conglomerate	39	0

	Ft.	In.
Gray arenaceous shale, with small *clay ironstone* balls desseminated. This has something of the character of underclay, but the *stigmariæ* are not distinct....	4	0
Gray arenaceous shale	1	0
Gray argillaceous shale	3	0
Gray arenaceous shale	3	0
Gray argillaceous shale, with some balls of *clay ironstone*	5	0
Gray arenaceous shale	1	0
Gray argillaceous shale with 2 beds of arenaceous shale	8	0
Greenish gray sandstone in regular beds	61	0
Greenish gray sandstone, with cabonized drift plants, and occasional patches of concretionary nodulous limestone, very like conglomerate	63	0
Greenish gray sandstone with carbonized drift plants..	1	0
Greenish gray sandstone fit for grindstones	20	0
Gray concretionary limestone, very like a conglomerate with calcareous pebbles	4	0
Greenish gray sandstone	25	0
Lead gray concretionary limestone with carbonized drift plants, and mixed up with calcareous sandstone	8	0
Gray argillaceous shale	10	0
Red or chocolate coloured argillaceous shale	40	0
Dark gray coarse limestone, no organic remains visible	1	0
Gray argillaceous shale	1	0
9. COALY matter and *carbonaceous shale*	0	2
Gray argillo- arenaceous shale, resembling fireclay, with the leaves and branches of *stigmariæ ficoides* strongly marked, the branches recumbent, and near the top of the bed *ironstone* balls are disseminated through the deposit (*underclay*)	5	0
Gray argillaceous shale and greenish gray sandstone..	2	0
Gray argillaceous shale	2	0
Red argillaceous shale	5	0

	Ft.	In.
Greenish argillaceous shale	7	0
Greenish gray sandstone	96	0
Greenish concretionary limestone	2	0
Greenish gray hard sandstone with a number of large spherical masses still harder. Some of them are 1 foot in diameter, and in section exhibit beautiful deep black and bright red concentric circles towards the exterior. These spheres are said to be occasionally 4 feet in diameter. This constitutes DOGFISH REEF	20	0
Greenish concretionary limestone, the calcareous concretions are lodged in an argillaceous matrix	1	0
Gray argillaceous shale	12	0
Greenish gray sandstone	6	0
Measures concealed, but supposed to be soft	3	0
Dark gray argillaceous shale with disseminated *clay ironstone* balls	10	0
Dark gray argillaceous shale with a course of *clay ironstone* balls at the bottom, some of them 6 inches in diameter	5	0
Black carbonaceous shale, with *shells* in some parts	4	0
Dark gray argillaceous shale	0	10
Dark gray argillaceous shale with a course of poor *ironstone* balls at the top, making about ½ inch	8	0
Greenish gray sandstone fit for grindstones	17	0
Greenish concretionary limestone, having much the appearance of a calcareous conglomerate	3	0
Greenish gray sandstone	5	0
Greenish gray sandstone with carbonized drift plants, *calamites* and others squeezed flat	3	0
Brown argillaceous shale	1	0
Greenish gray sandstone	1	0
Reddish gray shale	1	0
Measures concealed, probably shale	77	0

	Ft.	In.
Red or chocolate coloured sandstone	3	0
Red or chocolate coloured arenaceous shale	7	0
Red or chocolate coloured sandstone and shale	21	0
Red sandstone	1	0
Red shale	1	0
Red sandstone	6	0
Red shale	1	0
Red sandstone	2	0
Red arenaceous shale	1	0
Red sandstone	10	0
Red shale	2	0
Red sandstone	0	6
Red shale	0	8
Dark green limestone	0	4
Red shale	3	0
Red sandstone	2	0
Red argillaceous shale	6	0
Greenish argillaceous shale	0	3
Red or chocolate coloured shale	1	0
Red or chocolate coloured sandstone	1	0
Red or chocolate coloured shale	8	0
Black bituminous limestone	0	3
Red or chocolate coloured shale	1	0
Black bituminous limestone	0	6
Red or chocolate coloured argillaceous shale	1	6
Black bituminous limestone, with *fish scales*	0	6
Brownish red soft shale	52	0
Red or chocolate coloured shale	18	0
Greenish gray sandstone	9	0
Red shale	37	0
Black bituminous limestone, with *fish scales*	0	6
	3240	9

RECAPITULATION.

					Ft.	In.
COAL in 9 seams			0	10		
Carbonaceous shale associated with the coal, and in one instance without coal, and then containing remains of shells			7	4		
Bituminous limestone with remains of fish, and calcareous beds, associated with the coal and carbonaceous shale seams in one instance, and in six instances independent			4	10		
Greenish and gray argillaceous shale, associated in some instances with the coal and carbonaceous seams......			9	1		
					22	1
Underclay or understone, being beds of various material, immediately subjacent to the seams of coal and carbonaceous shale, and invariably penetrated by the recumbent branches and radiating leaves of the stigmaria ficoides. Every one of the coal seams rests upon a stigmaria bed, and there is one instance of the stigmaria bed without superincumbent coal. The material of which the stigmaria beds consists, is as follows:						
Sandstone of a gray colour and crumbly quality			5	0		
Shale—						
Gray argillo-arenaceous, frequently fit for fireclay	50	0				
Green argillo-arenaceous..	21	0				
Red and green argillo-arenaceous	17	0				
			88	0		
					93	0

	Ft.	In.	Ft.	In.	Ft.	In.
Sandstone—						
Greenish gray or drab coloured, of which much is fit for the purpose of good grindstones, and it is in it that the chief quarries of the Joggins exist. Of this mass 350 feet in various parts are filled with vast collections of drift plants, coated with crystalline coal. The plants are in general confusion, and are in general prostrate. Spherical concretions, some 4 feet in diameter with a rusty black exterior, occur in 51 feet of it..........	1886	6				
Greenish	2	0				
Yellow of a finer but less durable quality than the drab	25	0				
Reddish gray (and gray 5).....	19	6				
Red and green	15	0				
Red and chocolate coloured	95	6				
			2043	6		
Limestone of a concretionary character very much resembling conglomerate generally of a greenish colour and in very irregular layers			43	0		
Shale—						
Greenish gray arenaceous and argillaceous	136	0				
Gray arenaceous and argillaceous with a few small beds containing ironstone balls	234	0				
Red and green variegated	77	0				
Red and chocolate coloured	592	2				
			1039	2		
					3240	9

(Among the organic remains is to be remarked one upright sigillaria.)

7

	Ft.	In.
Measures concealed	19	0
Red arenaceous shale	1	0
Measures concealed	37	0
Red arenaceous shale	1	0
Measures concealed, probably red shale	139	0
(Here is said to occur a bed of gypsum. I am informed that it has been occasionally seen when the beach was washed clean by the tide. A fragmentary mass of gypsum about half a hundred weight lay on the beach.)		
Measures concealed, probably red shale	85	0
Red sandstone conglomerate with white, red, yellow and black silicious pebbles. The black is lydian stone, the others are quartz. The pebbles vary in size from that of a pea to that of a hen's egg	105	0
Red sandstone conglomerate of a coarser quality. The pebbles are of the same colour, but some of them would weigh two pounds	3	0
Red sandstone conglomerate, not quite so coarse	16	0
Red arenaceous shale with several bands of sandstone	21	0
Red sandstone	5	0
Red shale	3	0
Red sandstone	6	0
Red shale	3	0
Red sandstone conglomerate with white, gray and black silicious pebbles as before	16	0
Red sandstone	22	0
Red and green spotty variegated sandstone	11	0
Red sandstone of soft quality	3	0
Red and green spotty variegated sandstone. The green colour constitutes the spots which are circular with a black speck in the centre. The bed appears to be partly calcareous	9	0

	Ft.	In.
Red sandstone of a soft quality and red arenaceous shale	11	0
Red arenaceous shale	24	0
Red sandstone conglomerate with white, red and yellow quartz, and black lydian stone pebbles, varying in size from that of a pea to that of an egg	17	0
Red sandstone of a very coarse grit, with streaks of white parallel with the bedding	16	0
Red sandstone conglomerate with quartz and limestone pebbles. The matrix is coarse	4	0
Red sandstone with thin white streaks deposited in it. .	35	0
(This bed is cut by a regular vein of sulphate of barytes 3 inches wide. Its colour is tinged with red. The course of the vein is N. & S. The underlie E. < 82°.)		
Red sandstone conglomerate. The bed is very uneven and contains calcareous material	3	0
Greenish concretionary limestone, looking very like a conglomerate with limestone pebbles	8	0
Greenish gray sandstone	1	0
Greenish concretionary limestone as before	3	0
Reddish sandstone	7	0
Greenish concretionary limestone as before	5	0
Red or chocolate coloured shale	8	0
Red sandstone	2	0
Red or chocolate coloured shale	1	0
	650	0

RECAPITULATION.

Sandstone—						
Greenish gray	1	0				
Reddish	7	0				
Red and green	20	0				
Red	65	0				
			93	0		
Red with white streaks			51	0		
					144	0

			Ft.	In.
Conglomerate, with red, white, gray and yellow quartz and black lydian stone pebbles, in a matrix of red sandstone	148	0		
Limestone in concretionary nodules placed in a matrix of greenish sandstone and shale, occasionally associated with carbonized fragments of plants	16	0		
Shale—				
Deep red and chocolate red arenaceous. 62 0				
Measures concealed, but supposed to be of the same quality 280 0				
	342	0		
			650	0

8

	Ft.	In.
Greenish gray sandstone, red towards the top	12	0
Greenish gray arenaceous limestone, with a band of concretionary limestone, resembling conglomerate	6	0
Greenish concretionary limestone and coarse sandstone, with carbonized drift plants	1	0
Greenish gray sandstone	11	0
Greenish gray sandstone, with two bands of concretionary limestone	12	0
Reddish black and reddish brown shale, with beds containing calcareous septariæ	9	0
Dark gray sandstone, with nodules of concretionary limestone	2	0
Reddish black argillaceous shale, with nodules of ferruginous limestone	9	0
Greenish gray sandstone	30	0
Greenish concretionary limestone	1	0
Greenish gray sandstone	21	0

	Ft.	In.
Greenish concretionary limestone, with carbonized drift plants	3	0
Greenish gray sandstone	17	0
Greenish concretionary limestone	1	0
Greenish gray or drab coloured sandstone	4	0
Red shale	8	0
Red sandstone	12	0
Red shale, with some bands of soft red sandstone	37	0
Red sandstone of a soft quality	6	0
Red shale, with bands of red sandstone	40	0
Greenish gray sandstone	30	0
Greenish concretionary limestone	1	0
Greenish gray sandstone, 10 feet; greenish concretionary limestone, 2 feet	12	0
Greenish gray sandstone, at the bottom of which there is a layer of carbonized drift plants, occasionally replaced by *gray sulphuret of copper* invested with a thin pellicle of the *green carbonate*	8	0
Red shale	8	0
Red sandstone	17	0
Red shale	3	0
Greenish gray sandstone, at the bottom which is a layer of drift plants converted into coal, and occasionally replaced by *gray sulphuret of copper* invested with the *green carbonate*	6	0
Red shale	9	0
Red shale and red sandstone	10	0
Red shale	10	0
Red sandstone	7	0
Red shale	8	0
Red and greenish gray sandstone	19	0
Greenish gray sandstone, with drift plants converted into coal, and occasionally replaced by *gray sulphuret of copper* with *green carbonate*	1	0

	Ft.	In.
Red arenaceous shale	37	0
Red sandstone of a soft quality	16	0
Greenish gray sandstone	6	0
Red hard arenaceous shale	25	0
Reddish sandstone	13	0
Red shale	2	0
Greenish gray sandstone, with carbonized remains of plants	6	0
Greenish concretionary limestone, 2 feet; red shale, 1 foot	3	0
Greenish gray sandstone, with concretionary limestone and carbonized remains of plants at the bottom	11	0
Greenish gray sandstone, with one foot of red shale on top	3	0
Red shale	16	0
Red sandstone, with some of a drab colour at the bottom, with carbonized remains of plants and balls of argillaceous shale	12	0
Red arenaceous shale	3	0
Red sandstone	3	0
Red arenaceous shale	60	0
Red sandstone of a coarse quality	14	0
Greenish gray sandstone, coloured red in parts	10	0
Red arenaceous shale	4	0
Greenish gray sandstone, with remains of plants converted into coal	6	0
Red arenaceous shale	30	0
Red sandstone, fit for first quality flagging	15	0
Greenish gray sandstone, with many remains of plants converted into coal, and occasionally replaced by *gray sulphuret of copper* with a pellicle of *green carbonate* around it	6	0
Red arenaceous shale	14	0
Red sandstone fit for flagging	16	0

	Ft.	In.
Red arenaceous shale	16	0
Red sanstone fit for inferior flagging	3	0
Red arenaceous shale	100	0
Red sandstone fit for flagging	4	0
Red arenaceous shale	29	0
Red sandstone fit for flagging	6	0
Red arenaceous shale	39	0
Red sandstone fit for flagging	30	0
Red arenaceous shale, with two bands of red sandstone	19	0
Red sandstone fit for flagging	22	0
Red arenaceous shale	119	0
(Here is said to occur gypsum of a red colour, in small quantities, but the bank being rather obscured by debris it was not visible.)		
Red arenaceous shale	108	0
Red arenaceous shale, with bands of red sandstone	3	0
Red arenaceous shale	79	0
Red arenaceous shale, with bands of red sandstone	3	0
Red arenaceous shale	43	0
Red arenaceous shale, with green veins crossing it	19	0
Red sandstone	1	0
Red arenaceous shale	2	0
Red sandstone	1	0
Red arenaceous shale	39	0
Red sandstone, partly greenish gray	4	0
Red arenaceous shale	1	0
Red sandstone of a soft quality	3	0
Red arenaceous shale	12	0
Red sandstone	1	0
Red arenaceous shale	14	0
Red arenaceous shale of a hard quality, with a band of red sandstone above	9	0
Red sandstone of a soft quality	1	0
Measures concealed, probably red shale	4	0

	Ft.	In.
Red arenaceous shale, with a band of greenish gray sandstone above	14	0
Red arenaceous shale	10	0
Measures not well seen, but probably red arenaceous shale	27	0
Red arenaceous shale, with a band of red sandstone above	7	0
Red hard arenaceous shale	1	0
Measures concealed, but probably arenaceous shale	15	0
Red arenaceous shale	53	0
Measures concealed, but probably red arenaceous shale of the same quality as before. Here occurs SEAMAN'S BROOK, MILL COVE	75	0
	1658	0

(In the exact strike of the lower gypsum above mentioned, in its course to Hebert River, there is a sink-hole about half way, in which gypsum has been found by excavation; and where the strike would come upon the Hebert, a mass of the mineral, apparently in situ, is seen in the bank, with red shale on both sides of it. At such a distance to the north of this mass as gives a vertical thickness of 300 feet of subjacent red shale, there is exposed a deposit of limestone, which, with some associated strata, appears to be about 100 feet thick; and this may, therefore, be considered as terminating the foregoing section. The limestone contains organic remains, among which there is, in some abundance, a bivalve shell, which I recognize as identical with the *Producta Lyelli* of Windsor, in Nova Scotia.)

RECAPITULATION.

					Ft.	In.
Sandstone—						
Greenish gray, occasionally holding carbonized remains of plants, and in four instances the plants (underlying the sandstone) are replaced by gray sulphuret and green carbonate of copper	206	0				
Reddish	13	0				
Deep red	213	0				
			432	0		
Concretionary limestone associated with the greenish gray sandstone. The concretions are held in an argillo-arenaceous matrix. In one instance the whole of the bed is calcareous, and there occur 9 beds altogether			20	0		
Shale—						
Red arenaceous, sometimes more and sometimes less argillaceous.	1186	0				
Reddish black and gray, with calcareous septaria and nodules...	20	0				
			1206	0		
					1658	0

TOTAL THICKNESS.

No. 1	1617	0
" 2	650	0
" 3	2134	1
" 4	2539	1
" 5	2082	0
" 6	3240	9
" 7	650	0
" 8	1658	0
	14570	11

Section of Rocks from Shulie to Spicer Cove, Cumberland Co., N. S., in descending order.—By Hugh Fletcher, B. A., of the Geological Survey of Canada.

SECTION I.

ROCKS FROM SHULIE TO SAND COVE,

In descending order.

The section begins at a cove where the highest rocks come on top of the cliff. From this cove a school-house on the opposite side of Shulie river lies S. 22° E., and a little wharf near a point is N. 48½° E., the extreme tip of the point being N. 46° E.*

	Ft.	In.
1. Greenish gray and gray fine sandstone with irregular layers of conglomerate. Dip N. 68½° E. < 2°, but becomes southerly immediately down Shulie River	25	0
2. Red argillaceous shale	10	0
3. Gray fine sandstone in thick layers nearly massive, passing on the strike into conglomerate	8	0
4. Red marl	5	9
5. Red and olive-green marl, finely banded, passing on the strike into sandstone	5	3
6. Gray, very fine-grained, irregularly-bedded sandstone, passing into arenaceous shale. Cuts out all the shales; contains at one point a lenticular layer of coal, two feet long and two inches to half an inch in thickness and with these there are patches of yellowish underclay; passing in places into conglomerate with pebbles chiefly of pre-Carboniferous rocks	5	5
7. Red marl with layers of greenish calcareous flag; with very irregular interchanges	17	0

*All bearings in Mr. Fletcher's sections are magnetic. The sections were measured from 9th to 18th November, 1896.—*Ed.*

	Ft.	In.
8. Greenish gray sandstone, passing into conglomerate, more than half being in places conglomerate....	5	0
9. Greenish gray sandstone and conglomerate, irregularly mixed; in places nearly all conglomerate; many large fragments of carbonized plants. One band at the point nearest the wharf opposite is very fine and wavy..........................	25	0
10. Red marl with layers of harder shale	8	6
11. Reddish-gray, very fine, shaly sandstone	7	11
12. Red marl	8	0
13. Red flaggy sandstone in layers four inches thick and downward	3	0
14. Red marl	8	0
15. Red, somewhat massive sandstone in irregular blocks, passing into red flags. The top of the bank at the entrance of Shulie River	7	0
16. Red marl, with olive green blotches	2	6
17. Red shale, with greenish, harder, calcareous bands	2	0
18. Red marl	2	0
19. Red and gray, very fine, glistening sandstone in flaggy layers	5	0
20. Red marl of somewhat irregular thickness, from one foot four inches to four feet	2	8
21. Very fine gray sandstone in beds from four feet downward	10	0
22. Red and gray shale, lenticular, replaced by gray sandstone	1	3
23. Gray, very fine, massive sandstone with coal pipes.	10	0
24. Red marl with greenish and gray streaks; very irregular, sometimes all red	5	0
25. Gray sandstone with blackish stripes, interbedded with red marl; all more or less lenticular	6	0
26. Greenish-gray, very fine calcareous sandstone; lenticular	2	4
27. Red marl	1	4

	Ft.	In.
28. Reddish-gray, very fine sandstone in flaggy layers.	4	0
29. Light-gray fine sandstone with comminuted plants	16	4
30. Greenish argillaceous shale	3	0
31. Rusty-gray, fine sandstone, massive, passing in places into conglomerate, and in other places altogether into greenish argillaceous shale	5	0
32. Gray, very coarse, pebbly sandstone, full of prostrate trees, with veins of bright coal half an inch thick	10	0
33. Greenish, very fine sandstone, replaced by coarser sandstone	1	0
34. Greenish and reddish rusty-weathering marl, replaced by sandstone	1	0
35. Greenish and reddish, very fine, argillaceous sandstone, replaced by greenish-gray, pebbly sandstone	3	0
36. Red marl with layers of jointed sandstone and shale.	7	0
37. Very fine, coherent, calcareous sandstone, in two or three layers	0	9
38. Red marl	4	7
39. Gray flags, very fine and sandy, replaced on the strike by gray sandstone	6	9
40. Gray massive sandstone. Much thicker in places, but replaced by the lower band of red marl	3	0
41. Greenish crumbly marl	0	3
42. Red marl with a layer of harder rock	6	0
43. Reddish and greenish, mottled, flaggy, rubbly rock; replaced by greenish sandstone	2	6
44. Greenish-gray very fine sandstone, passing into gray pebbly sandstone	6	6
45. Gray and rusty pebbly sandstone, with very irregular surfaces. The rocks are unfit for grindstone; many of the layers show broken leaves and fruit of fossil plants, with sometimes large		

	Ft.	In.
46. Red marly rock, seen for a great distance on the strike with various replacements	2	0
47. Gray, fine, massive, rusty-weathering sandstone all replaced by red marl, and again by sandstone..	5	0
48. Red marl	4	6
49. Reddish sandy flags	3	0
50. Greenish-gray sandstone	2	1
51. Greenish argillaceous shale with a blackish streak at the top	2	0
52. Reddish and gray, very fine, flaggy sandstone....	4	1
53. Red marl, replaced by sandstone. The bottom of this bed is at water-level at a little brook......	7	0
54. Greenish-gray sandstone. An eight inch fault with up-throw on the south side	1	8
55. Red marl	7	6
56. Greenish-gray calcareous rock in two layers	0	10
57. Red marl. Another little fault with upthrow on the south side	5	6
58. Gray very coherent sandstone	1	2
59. Red argillaceous shale with greenish blotches....	2	6
60. Reddish-gray sandstone	2	10
61. Red argillaceous shale	4	0
62. Light-gray, very coherent, knobby sandstone.....	0	8
63. Gray and greenish-gray very fine sandstone......	5	0
64. Red sandstone and argillaceous shale	5	10
65. Reddish argillaceous shale with three layers of gray fine sandstone	9	0
66. Red marl and sandstone, replaced by the gray sandstone of No. 67	7	6
67. Gray sandstone at water level at the mouth of a tiny brook	2	0
68. Red marl	5	6
69. Gray fine sandstone in three layers, much thicker in places	2	6

	Ft	In.
70. Red marl	4	0
71. Greenish-gray sandstone with lenticular layers of red marl; blackish pebbly patches	4	4
72. Greenish and red argillaceous shale	1	6
73. Greenish argillaceous shale and flaggy sandstone. Dip S. 76°—52° E.< 4°	5	0
74. Red marl and gray sandstone in layers. Dip S. 80° E.< 4°	6	10
75. Light gray very fine sandstone, passing into red marl at the top and into arenaceous shale	8	0
76. Gray, coarse and fine, pebbly sandstone at the mouth of Fitzgibbon Brook	4	6
77. Greenish-gray conglomerate, with pebbles often larger than a hen's egg. Forms the base of the island on the south side of the brook. The lowest three feet is finer in places	24	6
78. Red marl	6	0
79. Reddish, rubbly, argillaceous sandstone with irregular thin layers of red marl	11	4
80. Red marl with layers of rubbly argillaceous sandstone	11	6
81. Reddish-gray, very fine, flaggy sandstone	4	0
82. Red jointed marl	2	6
83. Greenish and reddish mottled sandstone and arenaceous shale in alternate layers	21	0
84. Reddish-gray sandstone, a few inches on top passing into gray fine and coarse sandstone	6	0
85. Measures concealed in a cove at the mouth of a little brook	10	5
86. Light gray, fine, micaceous sandstone, blackened in places by minute plants; rusty spots, with coal pipes and greenish shale. Thickens in places by encroaching upon No. 87	10	0
87. Reddish and greenish argillaceous shale	4	6

	Ft.	In.
88. Gray fine sandstone in irregular layers	10	0
89. Greenish-gray argillaceous shale with harder layers of sandstone	3	6
90. Gray sandstone as before with lenticular layers of red shale	10	0
91. Red marl and sandstone	6	6
92. Greenish arenaceous shale	1	6
93. Gray pebbly sandstone, irregularly bedded	7	6
94. Greenish, soft, argillaceous underclay	0	3
95. Red marl	3	6
96. Gray sandy flags, not well seen	1	9
97. Measures concealed	2	9
98. Red marl and sandy flags	2	1
99. Gray pebbly sandstone at the mouth of a little brook	15	0
100. Red marl	2	6
101. Measures concealed at Cranberry Head to a little pond or marsh. Dip S. 23° E.< 4°	41	9
102. Light gray flaggy sandstone	5	6
103. Gray coarse pebbly sandstone with patches of conglomerate	5	6
104. Greenish and gray, reddish and rusty conglomerate with pebbles as large as a hen's egg; of irregular thickness	4	0
105. Gray coarse sandstone	9	0
106. Greenish argillaceous shale	0	3
107. Red shale	4	0
108. Reddish-gray sandstone, passing into gray fine sandstone	12	0
109. Greenish and gray and reddish argillaceous shale	3	6
110. Greenish and gray, rusty and reddish flaggy sandstone, and arenaceous shale with three patches of greenish coarse shale and coal-pipes; lenticular beds of conglomerate also	23	0

		Ft.	In.
111.	Greenish argillaceous shale	0	5
112.	Red argillaceous shale	1	0
113.	Greenish-gray and gray sandstone, passing into red marl and flaggy sandstone	9	0
114.	Red marl	6	6
115.	Greenish-gray argillaceous shale	1	0
116.	Gray, coarse, pebbly sandstone in thick layers	10	6
117.	Greenish arenaceous and argillaceous shale	1	7
118.	Red argillaceous shale and sandstone	6	6
119.	Greenish and gray very fine sandstone and arenaceous shale	6	11
120.	Greenish and reddish, mottled, nearly compact sandstone, passing into gray sandstone	5	0
121.	Gray and rusty sandstone in part pebbly and with patches of conglomerate	6	7
122.	Reddish-gray argillaceous shale	1	4
123.	Reddish, rubbly, argillaceous sandstone	4	0
124.	Red shale	4	6
125.	Red marl and sandstone in alternate layers	9	0
126.	Light gray arenaceous shale with a tinge of red on top, passing into gray flaggy sandstone; lenticular patches of greenish argillaceous shale and red marl, sometimes ten feet thick	23	0
127.	Greenish-gray argillaceous shale	5	0
128.	Light-gray fine flaggy sandstone	2	0
129.	Gray, coarse, pebbly sandstone with patches of conglomerate and a finer rock; in part very rusty with many streaks of coal and prostrate trees	29	0
130.	Measures concealed at the mouths of five little brooks, Clam Cove. Dip N. 66° E. <12°. The change of dip from S. E. to E. and then back to S. E. requires further examination. That it extends across this concealed interval is doubtful	493	0

		Ft.	In.
131.	Gray and rusty sandstone irregularly bedded; patches of fine conglomerate in lenticular masses sometimes six feet thick	15	6
132.	Red argillaceous shale and sandstone. Dip N. 66° E. < 12°	16	0
133.	Light gray and greenish flaggy sandstone	6	0
134.	Light greenish and bluish gray argillaceous and arenaceous shale	3	6
135.	Red marl	2	0
136.	Dark gray argillaceous shale	0	5
137.	Red and greenish, more or less concretionary rubbly shale	5	0
138.	Red and greenish mottled argillaceous flag	4	0
139.	Red and greenish argillaceous shale	5	6
140.	Reddish and greenish coherent sandstone, very fine and argillaceous	1	0
141.	Red marl with dark-greenish blotches and shaly layers	9	0
142.	Greenish and gray very fine wavy sandstone and shale	1	0
143.	Greenish and light gray very fine sandstone, full of carbonized plants	6	0
144.	Gray, coarse, pebbly sandstone and conglomerate	26	0
145.	Red marl with harder layers	17	6
146.	Greenish fine argillaceous sandstone in flaggy and shaly layers	4	6
147.	Light gray and rusty jointed sandstone of fine texture with broken plants, wavy, with lenticular patches of coal	17	0
148.	A lenticular layer of coal and pyrite in bands; from four to two inches thick	0	3
149.	Gray, rusty-weathering, irregularly bedded sandstone, with patches of conglomerate and wedges of coal. Many of the sandstones are false-bedded and hard to measure	20	0

		Ft.	In.
150.	Red and green argillaceous shale	0	6
151.	Gray fine sandstone, passing at the bottom into pebbly, coarse sandstone with pebbles as large as a hen's egg	10	0
152.	Greenish coarse nut-and-egg conglomerate	14	0
153.	Greenish argillaceous shale, passing into rusty coarse twisted sandstone with coal-pipes	1	9
154.	Rusty sandstone and fire-clay, light gray at the top	6	0
155.	Alternate layers of sandstone and conglomerate, replaced in part by greenish argillaceous shale	11	6
156.	Arenaceous shale replaced by argillaceous shale	2	0
157.	Gray massive sandstone, broken by irregular joints, with lenticular replacements of greenish and reddish shale	17	0
158.	Greenish-gray argillaceous shale	0	9
159.	Gray, rusty-weathering, fine sandstone with pebbly patches	10	0
160.	Greenish-gray argillaceous shale; in places replaced by sandstone	1	2
161.	Gray and greenish-gray flaggy sandstone, passing at the bottom into pebbly coarse sandstone	19	0
162.	Dark gray argillaceous shale, more or less lenticular	0	2
163.	Gray broken and jointed sandstone. All the sandstones contain comminuted carbonized plants	10	0
164.	Greenish flaggy sandstone with thin layers of red argillaceous shale. A three-feet fault with upthrow on the west side	9	0
165.	Red argillaceous shale, with thin band of greenish-gray coherent sandstone	9	6
166.	Gray rusty-weathering sandstone in somewhat flaggy layers, with small wedges of argillaceous shale. Another fault of nine feet five inches with upthrow on the west. Dip of fault N. 42° E. $< 67°$	12	6

		Ft.	In.
167.	Red argillaceous shale and greenish-gray argillaceous flags with wavy arenaceous shale in alternate bands, in part replaced by greenish sandstone	18	6
168.	Greenish-gray fine flaggy sandstone, becoming coarse at the bottom. A downthrow fault dips S. 60° W. < 85°. Another dips S. 28° W. < 85°, the amount of downthrow to the south being nine feet. The sandstone contains coal-pipes, and wedges of argillaceous shale. Here the bottom of No. 167 shows two inches of black coaly shale and the upper surface of the sandstone becomes rusty underclay. A little further south is a twenty-two feet upthrow on the south side, the dip being N. 43° E.< 28°. The faults are easily traced by the coaly shale	20	6
169.	Greenish-gray argillaceous shale	1	0
170.	Reddish and greenish sandstone in alternate layers thrown up a few feet on the south side. On the strike these beds pass at the bottom into dark argillaceous shale	11	6
171.	Gray arenaceous shale	4	6
172.	Greenish-gray and rusty conglomerate, jointed and with small lenticular layers of red and greenish argillaceous shale. In the joints are veins of barytes a quarter of an inch thick	6	6
173.	Greenish-gray and gray fine sandstone divided into two by a foot of greenish argillaceous shale. An upthrow-fault of perhaps twenty-five feet, not well seen, separates No. 172 from this sandstone	25	0
174.	Reddish argillaceous shale with blotches of greenish shale; passes in places into greenish shale	2	0
175.	Reddish, rubbly, argillaceous sandstone and shale in alternate layers, passing into sandstone with coal-pipes. No. 67 of Section II (See page 514).	12	0

	Ft.	In.
176. Gray jointed pebbly sandstone. At the water level on the point of Sand Cove and following for some distance to the southward, while still further south the sandstone of No. 173 comes to the water level	10	0
177. Greenish-gray conglomerate with layers of finer grit and of arenaceous shale	10	0
178. Greenish-gray and gray fine sandstone with a little coal, seen only on the reefs. The dip now turns to S. 12° W.< 18°. (All the bearings in these sections are magnetic). A number of small faults, not well seen now obscure the section which is repeated in ascending order towards the large brook that flows into Sand Cove, as in Section II.	27	0
Total thickness of section...............	1769	4

From the top of the 25 feet sandstone (No. 173 of Section I.) south along the shore at about 60 yards the dip changes to S.< 50°. At 155 yards, sandstone and conglomerate dip S. 20° W.< 25°. At 260 yards, a 3-inch band of black shale underlaid by fine sandstone dips S. 35° W.< 33°. At 365 yards, sandstone dips S. 84° W.< 31°, but seems at 475 yards to dip northerly at a very high angle. There is here every indication of a fault with a downthrow to the north. The dip at one point is overturned to S 1° E.< 69°; the red marl, sandstone and conglomerate to the northward are greatly altered, then for 17 yards farther the dip is westerly, while for the next 100 yards the shore follows the strike, the dip being towards the sea.

Few rocks are then seen to 560 yards where the dip is perhaps N. 45° E.< 20°, beyond which for 526 yards to the mouth of Sand Brook a sand beach conceals the rocks.

From the outermost reef a section was measured as follows:

Section II.

NORTH OF SAND COVE.

In descending order.

		Ft.	In.
1.	Rusty conglomerate with bands of gray sandstone. Dip S. 81 W. < 50°	35	6
2.	Rusty and light-gray fine sandstone in thick beds, seen at intervals on the reefs	60	0
3.	Rusty and greenish-gray pebbly sandstone and conglomerate	11	6
4.	Rusty and greenish-gray pea-and-nut conglomerate with many larger pebbles. Extends to the fault.	10	0
5.	Light-gray argillaceous shale with a layer of blackish coaly matter on the top	1	6
6.	Red argillaceous shale with layers of flaggy sandstone	10	0
7.	Greenish-gray and rusty nut-and-egg conglomerate. Little downthrows on the east side	10	0
8.	Reddish argillaceous shale with greenish layers and blotches	1	0
9.	Greenish-gray argillaceous shale with red bands	2	0
10.	Gray and greenish-gray, pebbly sandstone with irregular layers of conglomerate	7	0
11.	Greenish argillaceous shale and flags with reddish layers	12	6
12.	Greenish arenaceous shale with red spots and blotches	2	0
13.	Light-gray fine sandstone with coal-pipes and a few patches of conglomerate	12	0
14.	Rusty and gray pea-and-nut conglomerate	7	0
15.	Light greenish-gray fine sandstone with plants and patches of argillaceous shale	5	0

		Ft.	In.
16.	Red and green argillaceous shale. A band of black shale and coal 3 inches on top (p. 510)	1	0
17.	Light gray very fine sandstone with an underclay at the top	3	0
18.	Red argillaceous shale	1	3
19.	Greenish argillaceous shale	0	8
20.	Bright-red conglomerate, passing into red sandstone	1	0
21.	Light-gray fine sandstone with coal-pipes	7	0
22.	Greenish and gray pea-and-nut conglomerate	9	0
23.	Greenish argillaceous shale, passing into harder flags	1	2
24.	Greenish coherent flag	0	5
25.	Red argillaceous shale and sandstone or arenaceous shale and flags, faulted	14	0
26.	Light bluish-gray very fine sandstone	4	0
27.	Red flags with greenish layers and blotches	6	0
28.	Gray very fine sandstone with a reddish tinge	2	0
29.	Red argillaceous shale with layers of greenish sandstone	10	0
30.	Gray, coarse, pebbly sandstone	2	0
31.	Red argillaceous shale with bands of greenish, fine coherent, flaggy sandstone	12	0
32.	Light gray, ripple-marked sandstone with the footprints of some land animal	5	0
33.	Red argillaceous shale	0	6
34.	Light-gray and rusty very fine sandstone with small patches of conglomerate	12	0
35.	Red argillaceous shale and sandstone, not well exposed	10	0
36.	Greenish-gray very fine sandstone	1	6
37.	Red argillaceous shale, not well exposed but apparently not faulted	20	0
38.	Light-gray, fine, flaggy sandstone, with patches of conglomerate	10	0
39.	Greenish-gray and rusty sandstone and conglomerate mixed	5	0

	Ft.	In.
40. Red and green mottled argillaceous shale	1	0
41. Reddish sandstone with green spots	7	0
42. Red argillaceous shale with a layer of white clay near the top	10	0
43. Rusty-gray sandstone with a lenticular layer of greenish and reddish argillaceous shale	4	0
44. Red and green argillaceous shale	1	0
45. Greenish-gray and rusty, flaggy sandstone, with thin layers of red argillaceous shale	4	0
46. Red argillaceous sandstone, flag and shale	2	0
47. Greenish and gray, fine, flaggy sandstone with carbonized plants and argillaceous streaks	5	0
48. Greenish and gray, coarse, pebbly sandstone and conglomerate, with lenticular layers of greenish argillaceous shale	10	0
49. Red argillaceous shale with greenish flags........	15	0
50. Greenish, fine, flaggy sandstone	15	0
51. Greenish-gray and red argillaceous shale	3	0
52. Greenish-gray, fine, flaggy sandstone, lenticular ...	2	0
53. Red arenaceous shale	2	0
54. Red argillaceous shale with bands of red and greenish sandstone	30	0
55. Measures concealed	30	0
56. Gray, fine, flaggy and shaly sandstone	2	0
57. Rusty-gray fine sandstone, with pebbly patches	7	0
58. Measures concealed, probably soft	10	0
59. Gray and rusty, pebbly, coarse sandstone	7	0
60. Measures concealed	15	0
61. Rusty and gray, crumbly, pebbly sandstone with coal-pipes	15	0
62. Red argillaceous shale, not well exposed..........	18	0
63. Greenish and gray and rusty, pebbly sandstone, with plants and coal-pipes. The dip changes to easterly	25	0
64. Greenish-gray arenaceous and argillaceous shale...	5	0

	Ft.	In.
65. Red argillaceous sandstone with greenish patches, rubbly and in irregular beds	8	0
66. Red argillaceous shale with a light greenish clay-parting at the top. Thinner in places	9	0
67. Reddish arenaceous shale with greenish blotches and layers	2	6
68 Greenish and gray arenaceous shale; passes into fine sandstone	2	6
69. Rusty-gray, fine sandstone with streaks of argillaceous shale. To the water-level at the point of Sand Cove. No. 176 of Section I.	5	0
Total thickness	597	0

There is probably no break in this section which repeats the measures of Section I. as far as the fault.

Across Sand Brook, at 344 yards farther south, gray pebbly sandstone in a cliff dips N. 75 E.< 19°. Including all the rocks to the top of this and the succeeding cliffs, the section is as follows:

Section III.

SOUTHWEST OF SAND COVE,

In descending order.

1. Gray sandstone	20	0
2. Red argillaceous shale and sandstone	40	0
3. Gray sandstone with pebbly patches	20	0
4. Red argillaceous shale with harder layers of reddish anud greenish sandstone. Some layers of reddish sandstone are of coarse texture	55	0
5. Gray fine sandstone in broken layers. Thin bands of greenish argillaceous shale and beds of arenaceous shale; coal streaks; very thin patches of pebbly rock	66	0
Total thickness	201	0

The first cliffs include only Nos. 4, 5 and ten ft. of 3. Then a downthrow fault on the south side brings red rock against the gray sandstone the whole height of the cliff, the displacement being probably sixty feet nearly vertical in a southeasterly direction. Further along, at another downthrow, a bed, perhaps 3. is seen to be twenty feet thick, while overlying come 2 and 1 as given in the section.

Outside on the point, a band of sixty feet of fine gray sandstone is overlaid by red rocks and gray sandstone at another fault.

Again a thick sandstone, perhaps 5, comes on the shore and is faulted. This is nearly all of fine texture, whereas further along the shore there are bands of coarser material. It seems possible that for all this distance the same sandstone (5) runs along on the strike, broken by many little faults.

Then comes a thickness of seventy-five feet of red rocks with conglomerate bands nearly horizontal. Then a heavy gray sandstone with a band of conglomerate twenty feet thick, greenish and reddish and gray, underlaid by pebbly sandstone.

Towards Sand River the section is in ascending order, red shale, sandstone of coarser texture with more conglomerate being abundant as far as a clean cliff of sandstone, nearly all fine, about 100 feet high. The highest beds at Sand River show thin layers of shale. A descending section is as follows:

SECTION IV.

FROM SAND RIVER EASTWARD,

In descending order.

	Ft.	In
1. Red marl with green layers, broken in the bank, beneath the first house behind the Post Office at Sand River. Dip S. 19° W. < 20° to 44°. Thickness undefined	5	0

	Ft.	In.
2. Gray and greenish, fine, wavy sandstone and arenaceous shale, with rusty spots and small streak of coal	15	0
3. Red marl with flaggy layers and greenish blotches and bands	6	6
4. Reddish, somewhat massive, fine sandstone and argillaceous shale	3	0
5. Red marl with irregular bands of harder flags. Dip S. 11° W. < 27°	13	0
6. Red, very fine sandstone, in two wedge-shaped layers	1	6
7. Red marl	2	0
8. Red sandstone with greenish blotches	1	6
9. Red marl with light green blotches	3	6
10. Red argillaceous sandstone and flag with green patches	1	6
11. Red marl or argillaceous shale with thin harder layers	10	8
12. Greenish, coherent, argillaceous flag	0	4
13. Red marl with two thin layers of sandy flag	4	6
14. Red argillaceous sandstone with green blotches; passes into argillaceous shale	2	0
15. Red argillaceous shale with green pipes and blotches	7	6
16. Gray or rusty fine grit	1	6
17. Red argillaceous shale	2	0
18. Greenish and rusty gray very fine sandstone with a few pebbles, rusty spots and coaly blotches	7	0
19. Greenish or bluish-gray argillaceous shale	6	0
20. Greenish-gray arenaceous shale and flaggy sandstone	1	4
21. Greenish and bluish-gray argillaceous shale; passes into sandy flags	2	0
22. Greenish-gray flaggy arenaceous shale and sandstone	5	0
23. Reddish argillaceous shale with greenish thin layers and blotches	12	0
24. Reddish flaggy sandstone	1	6

	Ft.	In.
25. Red argillaceous shale with a layer of rubbly fine sandstone	13	0
26. Reddish sandstone with green patches	2	6
27. Red crumbly argillaceous shale with four layers, sometimes lenticular, of arenaceous flag	22	0
28. Greenish-gray and rusty fine arenaceous shale and sandstone, blackened with comminuted carbonized plants; rusty and coaly spots; small lenticular basins of greenish argillaceous shale; has in places an Indian-red tint. The water-level of the base of the sand bar is at 31 feet, the rest of the measurement being on the outer shore. The layers are usually thick, very irregular, and in the lower part occur a few pebbles as large as a hen's egg. Dip at the bar S. 5° E $<$ 25°	75	0
29. Red argillaceous shale	10	0
30. Greenish-gray, gray and rusty, coarse sandstone with patches of pea-and-nut conglomerate; pipes and gash-veins of coal from one inch downward	12	0
31. Greenish-gray argillaceous shale	5	0
32. Gray and greenish, flaggy, fine sandstone	12	0
33. Red argillaceous shale	8	0
34. Greenish-gray shaly sandstone or arenaceous shale	12	0
35. Rusty-gray thick-bedded sandstone, with a few small pebbles	15	0
36. Red argillaceous shale	7	0
37. Greenish-gray arenaceous shale, passing into sandstone	13	0
38. Rusty gray fine sandstone, jointed into rectangular blocks, with pebbly patches	8	0
39. Greenish and bluish-gray argillaceous shale, of irregular thickness	2	0
40. Greenish-gray arenaceous flag	4	0

	Ft.	In.
41. Light-gray and greenish-gray, false-bedded, rusty-weathering sandstone, of somewhat loose texture; coal-pipes and pebbly patches	25	0
42. Rusty-gray and greenish pea-and-nut conglomerate with larger pebbles	5	0
43. Greenish-gray and rusty, very coarse, pebbly sandstone in irregular beds, for the most part thick-bedded	67	0
44. Greenish and rusty nut-and-egg conglomerate with finer bands	8	0
45. Reddish argillaceous shale with greenish and dark layers and blotches, probably No. 5 of next section	5	0
46. Greenish-gray arenaceous shale	1	6
47. Reddish-gray argillaceous shale and flags	4	0
48. Reddish-gray sandstone in bands	4	0
49. Red argillaceous shale	8	0
50. Greenish arenaceous shale and flaggy sandstone	2	0
51. Rusty, thick-bedded, fine sandstone	7	0
52. Red argillaceous shale with greenish bands and blotches. Dip S. 5° E. $<$ 18°	2	0
53. Red and green argillaceous shale with harder flags	5	6
54. Reddish argillaceous shale with fewer green blotches	2	0
55. Greenish and reddish arenaceous shale	1	0
56. Gray and rusty fine sandstone, false-bedded and in thick layers	11	0
57. Gray sandstone of the same texture, but pebbly	3	0
58. Greenish pea-and-nut conglomerate, in irregular bedding	1	6
59. Rusty and gray pebbly sandstone. Dip S. 21° E. to S. 14° E. $<$ 16° to 23°	3	0
60. Greenish-gray and rusty conglomerate and fine sandstone mixed in lenticular beds. Below No. 60 the beds do not appear in the cliff but only on reefs below high-water	7	0

		Ft.	In.
61.	Greenish-gray conglomerate	5	0
62.	Greenish-gray sandstone	5	0
63.	Greenish and reddish, mottled argillaceous shale with harder flaggy bands	12	4
64.	Greenish sandy flags and sandstone in a massive bed; conglomerate at the bottom	5	0
65.	Measures concealed. Red marl and greenish argillaceous coherent flags seen on the reefs	13	0
66.	Greenish-gray and gray fine sandstone	30	0
	Total thickness	579	2

Here the section is broken by a fault with a downthrow of considerable amount to the east, its dip being east and hade nearly vertical. The throw could not be determined, but perhaps the following beds succeed as indicated.

Section V.

BETWEEN SAND RIVER AND SAND COVE.

1.	Greenish-gray sandstone like No. 43 of Section IV. Dip S. 2° to 5° W.< 14° to 24°	75	0
2.	Greenish argillaceous shale passing into sandstone.	3	0
3.	Greenish-gray argillaceous shale passing into sandstone	5	0
4.	Greenish-gray and gray fine sandstone with some layers of greenish argillaceous shale	20	0
5.	Red argillaceous shale. Possibly No. 45 of the previous section	2	0
6.	Red marly sandstone	6	0
7.	Red argillaceous shale with greenish layers	2	0
8.	Rusty and greenish fine sandstone, with carbonized plants and pebbly patches	10	0
9.	Gray and rusty pebbly sandstone, with small patches of pea-and-nut conglomerate and veins of coal one inch thick and downward	5	0

	Ft.	In.
10. Greenish and rusty nut-and-egg conglomerate; passes partly into sandstone	10	0
11. Rusty and greenish-gray pebbly sandstone, irregularly bedded	10	0
12. Red marl or argillaceous shale not well exposed	23	0
13. Reddish-gray and gray arenaceous shale and flaggy sandstone	3	6
14. Gray fine sandstone. Possibly No. 51 of Section IV.	5	0
15. Greenish-gray arenaceous shale, passing in part into red argillaceous shale	1	0
16. Gray and rusty fine sandstone with a few small pebbly patches at the bottom	10	0
17. Greenish-gray conglomerate; passes into pebbly sandstone	3	0
18. Greenish-gray pebbly sandstone	4	0
19. Greenish-gray and reddish argillaceous shale	4	0
20. Gray fine sandstone with coal-pipes, very irregularly bedded towards the top	12	6
21. Greenish and reddish argillaceous shale in alternate layers with harder flags	6	0
22. Greenish argillaceous shale and fine sandstone	4	0
23. Rusty-gray pebbly sandstone in irregular beds; coal-pipes and lenticular layers of argillaceous shale	25	0
24. Red argillaceous shale	7	0
25. Reddish-gray argillaceous sandstone	3	6
26. Red marl with a few greenish streaks	9	0
27. Rusty-gray pebbly sandstone; many fossil plants in some layers	10	0
28. Greenish-gray argillaceous shale	1	6
29. Rusty-gray pebbly sandstone as above	11	0
30. Red argillaceous shale and flags with greenish blotches at the bottom	9	0
31. Greenish and gray argillaceous sandstone in one layer	1	0

		Ft	In.
32.	Rusty-gray fine flaggy sandstone	5	0
33.	Greenish and gray argillaceous flags	2	6
34.	Red argillaceous shale; passes into rusty sandstone.	2	0
35.	Greenish fine sandstone	17	0
36.	Reddish argillaceous shale	5	0
37.	Greenish-gray shaly sandstone	4	0
38.	Red argillaceous shale	6	0
39.	Greenish arenaceous shale and sandstone, with prostrate trees and small lenticular layers of greenish argillaceous shale	20	0
40.	Red argillaceous shale and flags; passes into rusty sandstone with prostrate trees	1	6
41.	Greenish, fine, evenly-bedded arenaceous flags	2	0
42.	Red and greenish argillaceous shale and flags	1	6
43.	Greenish argillaceous shale and flags	3	0
44.	Rusty-gray, pebbly, thick-bedded sandstone with prostrate trees and patches of conglomerate	85	0
45.	Red argillaceous shale with greenish bands and streaks. The debris of the bank here obscures the section so that the thickness given for 44 may be too great	20	0
46.	Reddish sandstone	4	0
47.	Red argillaceous shale	5	0
48.	Reddish-gray fine sandstone	3	0
49.	Red argillaceous shale	5	0
50.	Reddish sandstone with green spots	2	0
51.	Red argillaceous shale	2	0
52.	Red sandstone	3	0
53.	Red argillaceous shale	5	0
54.	Red sandstone	2	0
55.	Red argillaceous shale	2	0
56.	Reddish sandstone	3	0
57.	Red argillaceous shale	1	0

		Ft.	In.
58.	Reddish sandstone and argillaceous shale in alternate beds	12	0
59.	Greenish-gray flaggy sandstone and argillaceous shale	2	0
60.	Rusty-gray, thick-bedded, very fine sandstone with a thin layer of argillaceous shale	5	0
61.	Greenish-gray argillaceous shale	2	6
62.	Very rusty fine and pebbly sandstone, passing into a mixture of gray conglomerate and sandstone	22	0
63.	Red argillaceous shale	8	0
64.	Gray pebbly sandstone with patches of conglomerate	5	0
65.	Greenish-gray conglomerate with patches of fine sandstone	15	0
66.	Greenish-gray, coherent, thick-bedded sandstone	15	0
67.	Measures concealed with perhaps one or more breaks. Dip S. 80° W. < 16°	22	0
68.	Greenish and rusty sandstone in a cliff	50	0
69.	Reddish argillaceous shale and sandstone	25	0
	Total thickness	310	0

Beds 68 and 69, instead of belonging to the base of the section, may be a repetition of some of those above. Several downthrows to the northeast then seem to repeat others, but are perhaps counterbalanced by faults with downthrow to the southwestward.

Ninety yards northeastward from the outcrop of 69, after two little downthrows have brought the red shale upon the beach, the gray sandstone (68) is in the cliff to a height of forty feet as before, the reefs striking apparently along the shore. About 275 yards farther east, red rock is capped in the cliff by gray and rusty sandstone, and at 140 yards still farther northeast is brought against greenish and gray sandstone by a fault. These latter are almost certainly the beds 45 to 58 of Section IV.; and the succeeding strata are those of Section III.

The direction of the line of fault is N. 53° W., with downthrow to the southwestward. At the last reefs, 225 yards west of the mouth of Sand Brook, the dip is S. 61° E. <15° to 22° near the landwash and N. 77° E. <10° farther seaward.

Ignoring faults, the strata west of Sand River appear to overlie those on the east side and may represent some of those between Sand Cove and Shulie. And unless there is a fault, the uppermost beds of the Pudsey Point section must be near, or repeat the lowest strata of Hetty Point. It may therefore be possible from the measurements to show the entire section from Shulie to Spicer Cove.

On the west side of Sand River the first rocks exposed dip N. 80°-83° E.< 21°, and their section is as follows:

Section VI.

WEST OF SAND RIVER,

In descending order.

	Ft.	In.
1. Gray fine sandstone with layers of dark-gray argillaceous shale; coal-pipes. Dip N. 82° E.<21°. At water-level 250 yards southwest of the end of the road to the beach	10	0
2. Gray, coarse, pebbly grit with layers of gray sandstone, full of carbonized plants	11	0
3. Red and green mottled argillaceous shales........	0	10
4. Light gray fine sandstone	7	0
5. Dark bluish-gray argillaceous shale, lenticular.....	0	6
6. Light-gray and greenish-gray fine sandstone, in thick irregularly jointed beds, with a few pebbly patches of grit, coarser at the bottom; for the most part very massive	49	0
7. Greenish argillaceous shale. Dip S. 15° E. <9° ...	0	9

A fault, the direction of which is S. 5° W. and the dip apparently S. 85° E.< 85°, seems to pro-

	Ft.	In.
duce this change of dip from east to south. A thin band of red and greenish argillaceous shale on the east side is lost against the sandstone on the west, and the amount of the fault may be more than 20 feet, for nothing is seen of the shale on top of the bank. Usually at these faults very little of the rock is turned on edge, the course being marked only by a quantity of soft clay or "gouge"; but here a block of 10 feet seems to have been dropped off the gray sandstone on the west side. This fault shows in the cliff 150 yards southwest of the first rocks, or 400 from the end of the road to the beach on the southwest side of Sand River.		
8. Red argillaceous shale. A two feet fault with a nearly vertical upthrow on the west side.......	19	0
9. Gray and cream-colored, massive, fine sandstone...	9	0
10. Greenish and gray coarse grit; cut out at one point and nearly all replaced by red argillaceous shale at a pillar-rock	22	0
11. Greenish and reddish argillaceous shale, replaced on the strike by sandstone	2	0
12. Reddish and greenish, mottled, argillaceous sandstone	6	0
13. Gray, coarse, pebbly grit and conglomerate.......	16	0
14. Red fine sandstone and argillaceous shale, replaced in part at the bottom by gray sandstone..........	10	0
15. Gray and greenish fine and coarse sandstone in thick beds, with thin lenticular patches of pea-and-nut conglomerate; coaly streaks associated with the coarser patches and some finer bands of gray arenaceous shale are full of broken carbonized plants. The bottom of the upper ten feet of this band is at water-level at the mouth of the Mile Brook, the lower, at the next little brook quarter of		

		Ft.	In.
	a mile further west. On the strike there are of course many changes. The upper part is in places fine arenaceous shale and at the mouth of this second brook patches of conglomerate contain pebbles of gray, fine, micaceous sandstone and shale almost certainly newer than Devonian. The bedding is very irregular and also the lenticular layers of conglomerate and greenish shale	77	0
16.	Red argillaceous shale with greenish blotches.....	9	0
17.	Greenish and reddish mottled argillaceous and arenaceous rock	5	0
18.	Gray sandstone like No. 15, the upper part being in places fine wavy arenaceous shale. Nearly all the pebbles of the conglomerate are of Pre-Carboniferous rocks, the layers varying from six feet to two inches in thickness	55	0
19.	Dark bluish-gray argillaceous shale, with bands of dark-reddish shale and lenticular layers of greenish very fine sandstone and shale; an upright *Calamite* with the bark converted into coal. The overlying sandstones are very rusty and full of broken carbonized plants	10	6
20.	Gray and rusty fine massive sandstone, jointed at right angles to the bedding; pebbly patches and lenticular layers of dark shale	23	0
21.	Rusty nut-and-egg conglomerate with pebbles up to three inches in diameter. Thicker in places, the sandstone cutting it out	4	6
22.	Red argillaceous shale with bands of light gray and greenish very fine, coherent sandstone	25	0
23.	Light gray very fine sandstone, with thin layers of red and gray argillaceous shale	15	0
24.	Red argillaceous shale interbedded with reddish fine sandstone	13	0

	Ft.	In.
25. Red crumbly argillaceous shale	7	0
26. Dark reddish and gray argillaceous flags	4	6
27. Gray fine massive sandstone, with lenticular patches of reddish and dark shale	6	6
28. Bluish-gray rubbly argillaceous shale	2	0
29. Red argillaceous shale with greenish-gray blotches and reddish sandstone in regular layers	14	6
30. Gray and cream colored fine flaggy sandstone	5	0
31. Red argillaceous shale with blotches and thin layers of greenish and gray shale	5	0
Total thickness	424	7

The dip, S.<41°, now takes the rocks out to sea and they are repeated on the shore from the bottom of No. 29, but reversed in the following section:

SECTION VII.

ROCKS REPEATED ON THE SHORE SOUTHWEST OF SAND RIVER,

In descending order.

	Ft.	In.
1. Coal in layers with pyrite, about fifteen feet long. It ends at a two feet fault with an upthrow on the left side, followed by a much larger fault, apparently a similar upthrow, which brings up the shale No. 3, the upper part of which is here red. No. 3 comes to the water level at a brook of some size, where the overlying sandstone contains lenticular bands of argillaceous shale. A little further west, behind a narrow point, there is another brook, at which again the dark shale is at water-level, but a short distance further it is replaced by pebbly sandstone, the whole cliff probably two hundred feet in height, being composed of pebbly sandstone dipping at a low angle	0	4

	Ft.	In.
2. Gray and greenish-gray and rusty massive sandstone with coal-pipes of large size; more or less pebbly. In some places sandstone occupies the whole height of the cliff, but in other places it shows a few inches of argillaceous shale	18	6
3. Greenish-gray and gray, rusty-weathering, somewhat rubbly argillaceous shale	10	0
4. Gray thick-bedded sandstone containing patches of conglomerate and a prostrate tree eight feet in length. The lowermost forty feet come to the water-level at the mouth of Two Mile Brook, where there are exposed overlying beds which dip S. 5° E.< 30°, and give a total thickness of 105 feet to the old dam at the head of the cove. Certain layers are coarse and pebbly, others fine and shaly, but none are fit for building stone, containing very irregular concretions. On the right bank of this brook there is a lenticular layer of greenish-gray argillaceous shale, five feet thick, overlaid by conglomerate and underlaid by fine sandstone, some of which, about eighty feet from the bottom of the mass, is of good grindstone grit. On the opposite bank some of the beds turn to red shale, but only for a few feet. There is a very persistent band of ten feet of this shale with reddish-gray sandstone. Below this horizon the rocks to the southwest change largely into conglomerate, the coast nearly following the strike of the rocks	105	0
5. Dark-gray argillaceous shale. Here occurs a downthrow on the west side, of considerable amount, at a tiny brook. None of the measurement is, however, lost	3	0
6. Red argillaceous shale and sandstone in alternate bands	25	0

	Ft.	In.
7. Greenish-gray argillaceous shale	3	0
8. Rusty-gray coarse pebbly sandstone, with finer layers and lenticular patches of conglomerate	50	0
9. Bluish-gray argillaceous flag, with concretionary arenaceous "bulls-eyes"	12	0
10. Gray and greenish and rusty pebbly sandstone; passes in part into conglomerate and contains lenticular patches of conglomerate and argillaceous shale	37	0
11. Rusty-gray nut-and-egg conglomerate. No. 21 of last section	4	6
12. Red sandstone and shale with greenish and gray layers and a lenticular layer of dark arenaceous shale	20	0
13. Greenish-gray and rusty fine sandstone. A 10-feet downthrow on the west side	10	0
14. Red sandstone and argillaceous shale in alternate layers	25	0
15. Red marl	10	0
16. Dark gray and greenish argillaceous shale	0	6
17. Reddish argillaceous sandstone	4	0
18. Gray, very fine sandstone	5	0
19. Bluish-gray argillaceous shale	1	6
20. Gray and greenish argillaceous shale, with pebbly patches	5	0
21. Red shale and light-gray and greenish fine sandstone, in alternate layers. No. 29 of previous section	14	0
Total thickness	363	4

Section VIII.

DESCENDING BELOW NO. 3 OF LAST SECTION.

	Ft.	In.
1. Gray pebbly sandstone of the usual character	20	0
2. Dark-gray argillaceous shale in a lenticular band ranging from ten feet to one inch	5	0

	Ft.	In.
3. Gray sandstone, fine on top but becoming pebbly below. 38 feet of this sandstone comes to water-level at the next little brook. With so much sandstone the measurement of some parts of the section is incorrect no doubt, but the bedding is usually plain	50	0
4. Red argillaceous shale with bluish and greenish layers; replaced by gray coarse pebbly sandstone.	5	0
5. Gray pebbly sandstone. In places the layers of shale are thicker and contain bands of gray fine sandstone	7	0
6. Greenish and reddish argillaceous rubbly rock; also replaced by gray sandstone	4	0
7. Rusty-gray or cream-colored fine sandstone, passing into coarse sandstone and intermixed with pebbly layers. In places it turns nearly all into nut-and-egg conglomerate. Lenticular layers sometimes six inches thick and ten feet long, show alternate bands of impure coal and pyrite. At ninety feet there is a landing place. Here the rocks are largely conglomerate and in certain bands this assumes a reddish tint as well as in patches of the finer sandstone. Some of the pebbles are of brick-red sandstone, others, of greenish-gray and gray micaceous sandstone, like Carboniferous. The lower part is very rusty and full of veins and blotches of coal	95	0
8. Greenish-rubbly argillaceous shale with red patches and layers	4	0
9. Gray-flaggy argillaceous sandstone with a lump of coal near the top	5	0
10. Greenish-gray and cream-colored alternations of fine sandstone, pebbly sandstone, and pea-and-nut conglomerate with larger pebbles; coal streaks and pipes	22	0

	Ft	In.
11. Reddish argillaceous shale. Al these bands are lenticular	5	0
12. Greenish-gray argillaceous shale. Thickens to the westward	2	0
13. Gray and rusty sandstone and conglomerate, irregularly mixed. This is on the strike for some distance, then the overlying No. 12 comes to the water-level. The top of No. 10 is at the water-level at the first little brook in Birch Cove. Here bands that represent Nos. 8 and 9 are, however, Indian-red, the material being still sandstone and conglomerate. Then rocks of a bright red color overlie to a height of fifty feet. Dip S. 47° W. < 20°	35	0
Total thickness	259	0

The top of 110 feet of reddish and gray sandstone and conglomerate, for the most part red, with coal-pipes, and veins of barytes in the joints, overlying No. 13, comes to the water-level at the second little brook in Birch Cove.

From this point 60 yards west, a large brook empties and a little brook comes into it. The brook turns from S. 15° W, the shore runs N. 53° W. to a headland, then trends more westerly. The top of the following descending section here comes to the water-level, probably about 13 feet below the top of the 110 feet above mentioned or 97 feet over No. 13.

Dip on the southeast side of the cove S. 8° W. < 14°.

Dip on the northwest side of the cove S. 60° E. < 12°; S. 24° to 17° E < 14° to 16° (mean dip S. 34° E. < 14°).

Section IX.

FROM BIRCH COVE WESTWARD TO HETTY POINT,

In descending order.

	Ft	In.
1. Gray and greenish-gray pebbly sandstone and conglomerate with thin lenticular layers of Indian-red conglomerate	52	0

	Ft.	In.
2. Greenish-gray, dark-bluish-gray and reddish argillaceous shale, the dark portions full of fossil plants	12	6
3. Gray and rusty fine sandstone, full of broken plants and having a one-inch lenticular layer of coal, sometimes in the bedding, sometimes in the joints	9	0
4. Greenish and bluish-gray pea-and-nut conglomerate	11	0
5. Gray and cream-colored pebbly sandstone, fin sandstone and conglomerate, a large proportion of which is conglomerate. It passes on the strike into Indian-red conglomerate, resembling that of Polly Brook and the Morang River, and soon it all turns to Indian-red. Many of the pebbles are as large as a cocoanut. Where coal-pipes are seen the rock is rusty and gray. Dip S. 21° E. < 15° . .	90	0
6. Gray fine flaggy sandstone with a nine-inch lenticular layer of greenish-gray argillaceous shale . .	6	6
7. Red argillaceous shale or marl. These beds are all lenticular and thin out	5	0
8. Mottled red and green argillaceous shale	2	0
9. Greenish and gray coarse grit and nut-and-egg conglomerate	45	0
10. Red argillaceous shale with greenish layers, cut out to form a fine cave behind a bluff	2	6
11. Red, rubbly, more coherent flag	0	11
12. Reddish sandstone with greenish blotches	0	10
13. Gray and greenish, fine, massive sandstone with broken plants	4	10
14. Gray and rusty fine sandstone, the upper surface of which is spotted with prostrate plants	3	0
15. Rusty-gray pea-and-nut conglomerate with layers of sandstone, the latter being blackened with carbonized plants. Veins of coal lie at various angles to the bedding, seldom exceeding half an inch in thickness. The gray sandstone is in very irregular		

	Ft	In.
wedges. Some of the pebbles are three inches in diameter; they consist chiefly of various gray Devonian rocks, but among them there are finer soft micaceous bluish-gray sandstone and shales, apparently derived from Carboniferous strata. Twenty feet to high water-level at the bluff about half a mile from Birch Cove Brook; and thirty-five feet to the bottom of the same cliff, but all cut out behind back to the band of red shale. Several fine prostrate trees occur, and on the strike some of these rocks turn again Indian or brick-red, although for the most part they are gray and rusty	12	0

The overlying band thins out, but again takes up in an attenuated form in a few places, the rocks following the coast for a great distance on the strike. The line of the red band (10 to 12) is occupied by a definite bedding-joint, into which lenticular small patches of argillaceous shale sometimes come, while above it about twenty feet and in other parts of the high cliff, there are thin layers of argillaceous shale.

Nearer McCarren Cove, the finer bands have a tinge of reddish or brown, and are nearly all pebbly. Further along, parts of the fine beds become fit for grindstone, the red bands in the cliff retaining their horizontal position, so that there is absolutely no doubt that this part of the section is on the strike. Dip not far from the cove, S. 23° E. $<15^\circ$, S. 7° E. $< 4^\circ$ to 18°. The section here below No. 9 is as follows:

1. Greenish-gray sandstone and argillaceous shale	2	9
2. Greenish-gray argillaceous shale with two layers of clay	1	6

	Ft.	In
3. Greenish-gray and reddish rubbly argillaceous sandstone	3	2
4. Reddish argillaceous shale with a lenticular layer of fine greenish sandstone	1	5
5. Red and green fine flags	2	6
6. Greenish and reddish very fine sandstone, in flaggy beds fit for grindstone, probably a part of No. 15 but very different in texture	2	8
7. Light gray very fine massive sandstone with pebbly patches, but no coarse layers	45	6

Beyond the bluff at which this section ends, conglomerate is again cut out in a cove, but the red band reappears on the next point, where the underlying sandstone is, however, somewhat pebbly, but only in places, for on the whole there is a distinct improvement in the texture. On the point west of Birch Cove the thickness of the sandstone was found to be forty-seven feet; on the next headland, forty-five feet six inches as above, whereas on the point near McCarren Cove, the lower part has turned into the section as continued below:

16. Red argillaceous shale	0	9
17. Greenish-gray argillaceous shale, with thin lenticular layers of greenish arenaceous rock	5	0
18. Clay parting	0	2
19. Greenish-gray arenaceous shale passing at the bottom into greenish, coarse, pebbly sandstone, with coal veins, two inches and downward, in gashes in the rock	10	0
20. Gray sandstone of fine texture almost fit for grindstone, but with pebbly patches in some of the massive layers. The lower part passes into conglomerate	15	0

	Ft.	In.
21. Gray conglomerate with lenticular patches of fine sandstone; all very coarse, some of the pebbles being three inches in diameter. Dip S. 5° to 9° W. <7° to 8°	6	0
22. Gray sandstone in thick layers, of fine grit but with pebbles. In texture the rocks generally resemble those of River John	12	0
23. Greenish-gray conglomerate	1	6
24. Gray fine sandstone of uniform texture, with very few pebbles	4	0
25. Measures concealed. Dip S. 34° to 33° E.	6	3
26. Gray or brownish sandstone seen only on the reefs; pebbles scattered throughout the mass and with some beds of conglomerate. Not all exposed, but seen in frequent reefs across McCarren Cove. Dip S. 34° E. < 16°.	265	0
27. Gray pebbly sandstone in thick beds. The first rock of the cliff north of McCarren Cove	15	0
28. Rusty-gray sandstone; irregular layers of pea-and-nut conglomerate; coal-pipes and veins	31	0
29. Reddish and greenish lenticular argillaceous shale, replaced entirely at both ends by the sandstone and containing layers of sandstone	9	0
30. Light gray sandstone, in thick beds, with a few pebbles. Some beds have a reddish tinge and some are fit for grindstones. Other small lenticular replacements occur. A very large proportion of the lower beds on the outer shore is of fine grain and without pebbles. At the first point, a thickness of forty-five feet is exposed, then higher beds appear in a rough cove. Dip, about the middle of the point, S. 45° E. < 12°; in places large regular flags break out and the bottom becomes more shaly	70	0

	Ft.	In
31. Red argillaceous shale with bands of reddish arenaceous shale; layers of greenish or whitish-gray calcareous, fine sandstone and of bluish-gray shale in a deep little cove....................	50	0
32. Greenish and rusty-gray fine grained arenaceous shale and sandstone, with carbonized plants; cut into long blocks by irregular joints; some pebbly patches occur towards the bottom, but the fine beds greatly predominate. Changes in the lower part into Indian-red sandstone like that of Birch Cove	68	0
33. Red argillaceous shale with greenish thin bands...	15	0
34. Indian or brick-red fine sandstone with pebbly patches containing layers of arenaceous shale, precisely like the greenish and gray varieties except in color; shows the usual whitish and greenish blotches of the red rocks. At the lighthouse on Hetty Point, the red layers are underlaid by gray or brown, and these latter replace certain beds on the strike	58	0
35. Greenish-gray and rusty fine sandstone with very few pebbles, generally in thick beds, some patches very rusty; in part concertionary, with "bulls-eyes"; many of the beds have wavy lines. Certain layers at the bottom turn into red. Almost the whole thickness may be said to lie below high water on Hetty Point and to extend to the lowest point seen on the reefs	140	0
Total thickness	1038	9

The beds now rise on the right bank of Apple River. They appear to be but very little higher than the strata of the following section at Pudsey Point on the opposite side of the river, or may represent a portion of the latter.

SECTION X.

AT PUDSEY POINT AT THE MOUTH OF APPLE RIVER,

In descending order.

		Ft.	In.
1.	Gray sandstone, with a few pebbles	5	0
2.	Greenish-gray conglomerate with occasionally a tinge of red; pebbles six inches and downward, the matrix always of coarse grit; small lenticular masses of finer rock	15	0
3.	Red argillaceous sandstone with greenish streaks	1	6
4.	Dark-gray, fine, flaggy sandstone with layers of dark argillaceous shale, in part almost carbonaceous shale	5	0
5.	Reddish fine sandstone mixed with conglomerate and in part replaced by the dark sandstone; streaks of coal at the bottom	5	0
6.	Reddish conglomerate with lenticular layers of reddish shaly sandstone	10	0
7.	Reddish sandstone, with lenticular layers of dark bluish-gray shale	5	0
8.	Reddish somewhat finer conglomerate	6	0
9.	Reddish and dark-gray and greenish argillaceous sandstone and shale, in lenticular irregular beds, all of which pass into conglomerate	8	0
10.	Reddish nut-and-egg conglomerate	7	0
11.	Reddish and greenish-gray, rubbly, very fine sandstone and argillaceous shale	12	0
12.	Reddish and gray conglomerate	5	0
13.	Greenish-gray and reddish sandstone and argillaceous flags	10	0
14.	Gray, fine, flaggy sandstone	3	0
15.	Reddish and gray sandstone with beds of bluish-gray argillaceous shale	2	6

	Ft.	In.
16. Reddish, coarse, thick-bedded sandstone	4	6
17. Greenish argillaceous shale	1	0
18. Reddish, coarse sandstone, with partings of argillaceous shale	7	6
19. Greenish-gray argillaceous shale	3	0
20. Greenish-gray and rusty conglomerate, replaced by No. 19 and again passing into reddish conglomerate; thin layers of reddish sandstone. The bottom is at water-level on the beach at a pillar-rock....	11	0
21. Reddish and greenish sandstone and argillaceous shale in a lenticular layer	4	6
22. Reddish conglomerate with thin layers of arenaceous shale and sandstone	7	0
23. Rusty arenaceous shale with reddish argillaceous and arenaceous shale	6	0
24. Red argillaceous shale with layers and blotches of reddish and greenish mottled sandstone	11	0
25. Reddish pea-conglomerate, with finer layers; passes into greenish conglomerate	10	0
26. Greenish and reddish flaggy argillaceous sandstone; lenticular	4	0
27. Reddish conglomerate with thin layers of reddish arenaceous shale and sandstone; passes into greenish conglomerate	7	0
28. Brick or triassic-red sandstone, of very coarse grit, in thick beds; changes into conglomerate	5	0
29. Reddish and greenish flaggy fine sandstone and argillaceous shale	5	6
30. Light gray, pebbly sandstone, changing into greenish gray arenaceous shale, spotted with plants......	4	0
31. Measures concealed. Dip S. 31° E. < 8°. Reefs of greenish-gray arenaceous shale in place at intervals	21	6
32. Greenish-gray arenaceous shale and sandstone, of fine texture, seen on the reefs but not in the cliff..	10	0

	Ft.	In.
33. Gray flaggy sandstone and arenaceous shale with a few pebbles	4	6
34. Greenish-gray conglomerate	5	0
35. Greenish-gray argillaceous shale and sandstone	4	0
36. Greenish conglomerate, with pebbles more than six inches in diameter	5	0
37. Greenish and reddish argillaceous shale and sandstone	5	0
38. Greenish, pebbly sandstone in one bed; changes into conglomerate	2	0
39. Greenish conglomerate	4	0
40. Greenish and dark-gray argillaceous shale and sandstone	5	0
41. Greenish-gray fine conglomerate	4	6
42. Greenish-gray arenaceous and argillaceous shale	5	0
43. Rusty, knobby sandstone and greenish, pebbly sandstone and conglomerate, full of rusty concretions	12	0
44. Red argillaceous shale with greenish and bluish-gray layers	7	0
45. Measures concealed	5	0
46. Light gray sandstone of fine grindstone grit; some flaggy layers; has been quarried on Pudsey Point.	14	0
47. Rusty and cream-colored and gray conglomerate and sandstone in irregular beds	12	0
48. Gray shale and flaggy sandstone	6	6
49. Gray fine sandstone in part fit for grindstones, but in places of coarse grit	5	0
50. Light gray and rusty arenaceous shale, in part pebbly. Dip S. 83° to 65° E. < 8° to 11°	6	0
51. Measures concealed by a sand beach, but showing on the reefs rocks similar to the above, a reddish grit about 48 ft. 6 inches from the top, and a band of greenish-gray conglomerate immediately overlying No. 52.	74	0

	Ft	In.
52. Greenish arenaceous shale and sandstone with patches of fine grit. Dip S. 83° E.< 7°	5	0
53. Bluish-gray argillaceous shale full of plants......	0	6
54. Greenish-gray argillaceous sandstone with a few plants	2	0
55. Red argillaceous shale with green spots. These shale beds change to the westward	1	6
56. Greenish-gray, very fine massive sandstone, passing into red and green argillaceous shale on the strike	1	6
57. Reddish and greenish mottled argillaceous shale...	1	10
58. Greenish-gray fine sandstone with reddish spots and layers of arenaceous shale, passing into greenish conglomerate. These rocks are all regularly bedded. A fault throws them down five feet on the south side	7	0
59. Dark gray, rubbly, argillaceous shale	3	0
60. Greenish-gray sandstone with small patches of fine conglomerate; becomes finer on the strike. On the whole the beds are argillaceous	7	4
61. Dark gray argillaceous shale	1	6
62. Greenish-gray, fine, flaggy, argillaceous sandstone..	6	0
63. Greenish and dark-gray argillaceous shale	2	4
64. Clay with an eighth of an inch of coal...........	0	6
65. Greenish argillaceous shale	3	0
66. Greenish-gray, coarse, pebbly sandstone with patches of conglomerate; replaced by lenticular argillaceous shale	10	0
67. Red argillaceous shale with layers of reddish and mottled sandstone. An upthrow of four feet six inches on the south side	15	0
68. Greenish-grav fine conglomerate and pebbly sandstone, with coarser layers at the base	10	0
69. Greenish and gray, rubbly argillaceous shale and flags	10	0

	Ft.	In.
70. Gray and rusty and greenish nut-and-egg conglomerate	8	0
71. Red argillaceous shale	3	0
72. Gray and greenish flaggy sandstone	9	0
73. Gray and greenish and rusty, pebbly sandstone and grit	5	0
74. Reddish argillaceous shale with greenish layers, but essentially red	14	0
75. Greenish sandstone in one bed, replaced on the strike by shales and flags	1	4
76. Red argillaceous shale ,with layers of reddish sandstone	17	0
77. Greenish wavy sandstone and arenaceous shale	3	6
78. Cream-colored or rusty very fine sandstone, somewhat concretionary, like certain layers seen on Pudsey Point and also on Hetty Point; irregularly jointed and all fine. A vein of coal at the bottom, one inch thick, in an irregular joint	11	0
79. Nut-and-egg conglomerate	5	0
80. Gray, pebbly sandstone	2	4
81. Measures concealed. Reefs and broken banks of gray and greenish fine sandstone occasionally seen, from which, about the middle of the gap, grindstones have been cut; dip S. 56° E. < 7°	148	0
82. Greenish arenaceous shale	5	0
83. Rusty-gray pebbly sandstone, with concretionary "bulls-eyes" at the top. Very like certain rocks of Hetty Point	12	0
84. Dark or Indian-red pebbly sandstone, like that of Hetty Point; contains small patches of conglomerate	6	0
85. Greenish-gray, wavy, arenaceous shale, blackened in the bedding by plants, sometimes of large size	6	0
86. Red argillaceous shale	5	0

	Ft.	In.
87. Reddish or pinkish sandstone like that of Hetty Point; patches of conglomerate; in thick layers, sometimes flaggy	25	0
88. Indian-red argillaceous shale and flaggy fine sandstone	7	0
89. Greenish-gray, wavy arenaceous shale, passing into fine sandstone	5	0
90. Rusty or cream-colored fine, thick-bedded sandstone	4	6
91. Greenish-gray and dark-gray argillaceous shale, mottled with red	7	0
92. Reddish-gray and greenish, very fine argillaceous sandstone, changing at the bottom into gray sandstone in flaggy layers and on the strike into massive sandstone	15	0
93. Red argillaceous shale with bands of greenish and gray sandstone	15	0
94. Dark-gray argillaceous shale with films and streaks of coal	1	0
95. Light-gray underclay with *Stigmaria* rootlets	1	6
96. Red argillaceous shale changing into sandstone	1	0
97. Gray and dark-gray fine sandstone and arenaceous shale, full of plants	12	0
98. Dark-greenish-gray argillaceous shale	4	6
99. Red argillaceous shale changing into red sandstone	4	6
100. Dark-gray and greenish argillaceous shale	2	0
101. Reddish-gray and mottled, arenaceous flags and sandstone	6	6
102. Greenish and dark-gray argillaceous shale	1	6
103. Red argillaceous shale with greenish layers and lenticular bands of fine sandstone	10	0
104. Gray and pinkish, fine and coarse sandstone, in thick, irregular, jointed beds; pebbly patches, the pebbles being nearly all of syenite	25	0

	Ft.	In.
105. Reddish-gray nut-and-egg conglomerate, among the pebbles of which are some of gray sandstone, containing plants and perhaps Carboniferous, although the greater number are of red syenite, porphyritic felsite and various Devonian quartzites. Gray patches show carbonized markings of stems of plants	14	0
106. Pinkish and triassic-red, coarse sandstone, with pebbly patches; forms the great cape north of Spicer Cove. Dip S. 41° E.< 12°. The strike would apparently run the rocks against the conglomerate cliffs of the opposite side of the cove, which they appear to represent. Fine reddish sandstone and grit almost entirely replace the coarser beds on the strike. The lower 33 feet are repeated and the measures are then concealed by the beach of Spicer Cove	55	0
107. Measures concealed		
Total thickness	974	2

On the low shore northeast of the mill at Spicer Cove, several good reefs seem to indicate a continuity of low southerly dips between the cliff exposures and, consequently, an absence of faults. If there is no important fault, the measures of the following section may be a repetition of the rocks below No. 80 of Section X.

Section XI.

AT SPICER COVE,

In descending order.

	Ft.	In.
1. Gray sandstone	7	0
2. Greenish, reddish and dark-gray argillaceous shale, not well seen	6	0
3. Bluish-gray, coherent, argillaceous shale	1	6

		Ft.	In.
4.	Dark-bluish-gray, coaly shale	0	6
5.	Bluish, greenish and reddish argillaceous flags	6	0
6.	Dark-greenish-gray, rubbly argillaceous flags	3	0
7.	Blackish coaly shale	0	4
8.	Greenish argillaceous sandstone	1	0
9.	Greenish argillaceous shale	0	6
10.	Greenish argillaceous sandstone in flaggy layers	8	0
11.	Coal, lenticular, with an underclay. A fault with an upthrow of two feet on the south side	0	1
12.	Red and green mottled fine sandstone	1	6
13.	Reddish and greenish mottled argillaceous shale. An upthrow of five feet on the south side	0	8
14.	Greenish, fine, flaggy sandstone	8	6
15.	Dark-gray argillaceous shale and flag, almost a coal at the top	0	10
16.	Black coaly shale	0	2
17.	Greenish and reddish, mottled argillaceous shale	7	0
18.	Light gray fine sandstone	3	0
19.	Greenish argillaceous flags and shales	1	6
20.	Dark gray shale, coaly in places	1	0
21.	Black coaly shale yielding a dark streak	0	4
22.	Bluish-gray argillaceous shale	0	8
23.	Black coaly shale	0	1
24.	Dark, greenish-gray and rusty argillaceous underclay	1	0
25.	Gray and greenish, very fine sandstone, broken in the bank and perhaps faulted	1	6
26.	Reddish and greenish, mottled, somewhat coherent argillaceous rock	2	0
27.	Dark-greenish argillaceous shale with coaly layers	1	0
28.	Light gray wavy arenaceous shale and sandstone; an underclay with fine *Stigmaria*	2	0

The rocks are now obscured by a broken, faulted bank on a northeast and southwest roll

or anticline. About 60 yards to the westward there is the following section:

1.	Olive-green massive sandstone	3	6
2.	Dark argillaceous shale and bands of sanstone with large erect trees....	8	0
3.	Dark argillaceous sandstone	5	0
4.	Dark coaly shale	0	3
5.	Dark-gray fine sandstone	0	6
6.	Black coaly shale, in part clean coal.	0	4
7.	Dark-gray argillaceous underclay....	1	4
8.	Black coaly shale, passing into greenish argillaceous shale	0	6
9.	Greenish arenaceous underclay passing into sandstone	2	0
10.	Dark-green argillaceous shale	3	0
11.	Measures concealed	1	10
12.	Greenish-gray coherent arenaceous shale	3	0
	Total thickness	29	3

About 55 yards to the westward and perhaps separated from the foregoing by a fault, the following beds occur:

1.	Greenish and reddish argillaceous shale with layers of sandstone	14	0
2.	Coaly band	0	3
3.	Dark greenish shale with veins of coal.	1	6
4.	Greenish coherent sandstone	0	4
5.	Red argillaceous shale. Perhaps No. 26 of Section XI.	2	0
	Total thickness	18	1

At 70 yards farther west these broken sections end at a great cliff of conglomerate. They are perhaps a repetition of the beds of Section XI

Ft. In.

below No. 13, and No. 28 may rest directly upon the conglomerate, in which case that section may be continued as follows:

29. Red conglomerate with veins of barite and celestite near the top; its material is for the most part of syenite, and it is associated with red, thick, fine layers. The thickness here given is taken from the boring drilled by Mr. J. A. Johnson. (See Section XII.) 811 6

30. Red syenite of Devonian age, or more generally an obscurely granular and compact felsite and quartz-felsite, hornblende being scarce except in dykes and blotches of dark diorite, seldom more than ten to fifteen feet wide. An epidote breccia occurs near the contact of the conglomerate, and the felsite is so much brecciated as to resemble the conglomerate. These rocks in great cliffs occupy the coast south past Eatonville to Cape Chignecto, as shown on Sheet No. 100 (and 101) of the Geological Survey series of maps. A line of fault at the first beds of red conglomerate is indicated by the grooves as dipping N. 45° E.< 63°. First a little piece of the conglomerate is thrown on edge; then, further inland near a little brook from the south, the dark rocks with the black shale and coaly layers of No. 28 rest upon the conglomerate at a low angle apparently conformably. The thickness of the latter as given above is much greater than the height of conglomerate in the cliffs, overlying the syenite, and thus measures the downthrow of the fault at about 500 feet.

Total thickness 878 2

The section of the boring referred to on page 545, is as follows :

Section XII.

J. A. JOHNSON'S BOREHOLE AT SPICER COVE,

In descending order.

	Ft.	In.
1. Surface : reddish gravel and clay	8	0
2. Light-gray fine sandstone	1	0
3. Reddish coarse and fine rock	1	0
4. Light greenish-grey fine compact sandstone	6	0
5. Dark gray argillaceous shale with fossil plants	1	0
6. Light grey and reddish mottled argillaceous shale ..	28	0
7. Reddish sandstone	1	6
8. Reddish nut-and-egg conglomerate	3	0
9. Reddish fine micaceous sandstone................	5	6
10. Reddish conglomerate, coarse grit and sandstone ...	13	0
11. Reddish micaceous sandstone	2	0
12. Reddish conglomerate	1	0
13. Reddish-grey argillaceous shale	0	8
14. Black coaly shale and coal	0	8
15. Greenish argillaceous shale with *Stigmaria* and rootlets	0	6
16. Greenish-gray argillaceous shale	2	0
17. Greenish-gray and reddish shale showing graphite .	4	2
18. Reddish argillacous shale with greenish blotches showing fossil plants	2	0
19. Reddish-gray very hard sandstone	1	0
20. Reddish conglomerate with thin bands of reddish and greenish coarse grit, fine sandstone and argillaceous shale, of gray sandstone and shale, and dark gray argillaceous shale with streaks of coal.	811	6
21. Reddish granitic rocks	50	3
Total depth	943	9

A correlation of these sections seems to show that only about 498 feet of the base of Section IX at Hetty Point extend beyond the base of Section I (and II); that Sections IV, V and VI are wholly repeated in Section I, the general similarity of the strata of these four sections being evident.

A provisonal summary of the total thickness of strata from the uppermost Permian beds at Shulie River—the top of Logan's section—to the base at the Devonian syenite, south of Spicer Cove, may be given as follows:

	Feet.
Strata of Section I (Shulie to Sand Cove)...........	1769
" Section IX (Birch Cove to Hetty Point)....	498
" Section X (Apple River to Spicer Cove)....	793
" Section XI (Spicer Cove)................	811
Total thickness exposed in coast section...	3871

This conclusion, arrived at from comparison of the columnar sections, does not contradict the evidence obtained from a study of the dips, faults, etc., as may be seen on the accompanying maps, on which the position of the various sections has been laid down; but before accepting it, further comparison of the beds supposed to be equivalent might be made.

Of the rocks of the Upper Coal Formation on the opposite side of the basin, from Shulie toward Ragged Reef, Sir J. Wm. Dawson says:* "Fossils are not abundant; but *Calamites, Stigmaria, Lepidodendra* and large petrified trunks of the pine trees of the Coal Formation still appear. The general asuect of these beds is, to a great extent, similar to that of the Millstone Grit series."

And in regard to the strata of the base of the section the same writer observes: "At Mill Brook, southeast of Apple River, there is a bed of coal one inch in thickness, and dipping to the north at a small angle. It is associated with coarse sand-

*Acadian Geology, p. 155.

stones and conglomerate, and probably belongs to the Lower Coal Measures or Millstone Grit series, the marine limestones being apparently absent. At least this is the interpretation I should be inclined to put upon the appearances in connection with the fact that along the north side of the Cobequids, the marine Lower Carboniferous is either absent or overlapped by the higher beds of the series in all the localities which I have explored."

Note.—Besides the map accompanying these sections, the reader is referred to the Geological Survey's map sheets of Nova Scotia, Nos. 100 and 101, as well as to the forthcoming Nos. 81 and 102, with the bibliographies thereon given. The reader may also consult Sir William Dawson's *Acadian Geology*, pages 150-178, which treats of Logan's section.

ERRATA.

Page 420, lines 17 and 28, for ' darb" read *drab*; p. 421, l. 21, for "reck" read *rock*; p. 426, last line, for "calamities" read *calamites*; p. 427, line 30, for "grav" read *gray*; p. 441, last line, "carbonaceous shale" should be in italics; p. 451, l. 27, for "carbonaceous shale 0·4" read *Carbonaceous shale 1·0*; p. 451, l. 28, for "witht" read *with*; p. 452, omit line 1, "Gray argillo-arenaceous shale, with *stigmariæ* (under-"; p. 452, l. 15, for "the turns" read *then turns*; p. 452, l. 19, for "groved" read *grooved*; p. 455, l. 23, indent "Gray" one "em"; p. 473, l. 23, for "grenish" read *greenish*; p. 481, l. 22, for "no less 10" read *no less than 10*; p. 487, l. 2, for "desseminated" read *disseminated*; p. 489, l. 14, "Dark green limestone" should be in italics; p. 502, last line, add to "with sometimes large" the omitted word *trunks*, and carry out 5 ft. 6 in. in column of figures; p. 505, l. 31, omit comma after "flaggy sandstone"; p. 514, l. 13, to make sense more clear, place full stop after word "section," and for "which" read *It*; p. 530, l. 1, for "al" read *all*; p. 531, l. 7, for "fin" read *fine*; p. 535, l. 22, for "concertionary" read *concretionary*; p. 543, l. 32, for "Stigmaria" read *Stigmariæ*; p. 546, l. 24, for "argillacous" read *argillaceous*.

CONTENTS.

In order to assist the reader in consulting the foregoing geological sections, there given below a list of those sections and the place-names that are mentioned therein, with the pages on which they occur.

A. SECTIONS AT THE JOGGINS, FROM WEST RAGGED REEF TO MINUDIE (IN DESCENDING ORDER), BY SIR WILLIAM E. LOGAN.

B. SECTIONS FROM SHULIE TO SPICER COVE (IN DESCENDING ORDER), BY HUGH FLETCHER.

Supplementary Note to a Paper on "The Sunken Land of Bus."*—By H. S. Poole, D. Sc.

Having otherwise failed to obtain information respecting the origin of the above title, an enquiry was inserted in *Notes and Queries* and the following reply was shortly afterwards obtained :

" 'Sunken Land of Bus' (10 s, v. 509) is named after one of Sir Martin Frobisher's ships in his third voyage in 1578. The relation of the pretended discovery, given by Hakluyt (*Voyages of the English Nation*, vol. iii, 160 e, p. 93), runs thus : 'The Busse of Bridgewater, as she came homeward to the southeastward of Frieseland, discovered a great island in the latitude of 57 degrees and an half, which was never yet found before, and sailed three dayes alongst the coast, the land seeming to be fruitfull, full of woods and a Campion Country.'

"John Barrow in his *Chronological History of Vogages into the Arctic Regions* (Lond., 1818, p. 94) says that 'a bank has recently been sounded upon, which has revived the idea of the Frieseland of Zeno and the Busse of Bridgewater having been swallowed up by an earthquake.'

"A full summary of the subject of the Land of Bus is given by Mr. Miller Christy as appendix B to C. C. A. Gosch's *Danish Arctic Expeditions, 1605 to 1620*, Hakluyt Soc., Book I, 1897. See also *The Annals of the Voyages of the Brothers Nicolo and Antonio Zeno*, by Fred. W. Lucas, Lond., 1898."

Royal Library, Stockholm. (Signed) E. W. Dahlgren.

* See *Transactions of N. S. Institute of Science*, vol. xi, p. 193.

THE attention of members of the Institute is directed to the following recommendations of the British Association Committee on Zoological Bibliography and Publications :—

"That authors' separate copies should not be distributed privately before the paper has been published in the regular manner.

"That it is desirable to express the subject of one's paper in its title, while keeping the title as concise as possible.

"That new species should be properly diagnosed and figured when possible.

"That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

"That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules of quotations, such as that recently adopted by the French Zoological Society"

THE

PROCEEDINGS AND TRANSACTIONS

OF THE

Nova Scotian Institute of Science,

HALIFAX, NOVA SCOTIA.

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SESSION OF 1905-1906.

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CONTENTS

TRANSACTIONS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1905-1906

ON THE FLORA OF MCNAB'S ISLAND, Halifax Harbour, N. S.: Part 1, General Notes; Part 2, Work in Special Orders; Part 3, Narcotisation of Plants; Part 4, Occasional Notes.—BY CAPTAIN JOHN H. BARBOUR, M. D., Royal Army Medical Corps.

(Read 13th. November, 1905.)

PART I.—GENERAL NOTES.

It is not my intention to deal fully with the flora of this island. I intend rather to just mention some of the principal things which struck me personally, leaving it to others who know the locality much better than I do, to fill in the details in after years, if this has not been already considerably done by observers in the neighbourhood of Halifax.

When we consider the position of the island, its size, the winters which occur, and the presence of the ocean around it, I think that we have on it a most wonderful variety of flowers, and the botanist may there find plenty of work to do in all departments, for he comes across woodland, littoral, meadow and sea plants growing in profusion within a small area.

One great peculiarity that one notices, is that the woodland plants descend right on to the shore, even to high-water mark.

and in fair numbers also. Never do I remember seeing so many woodland plants on one shore before, especially on the side of an island or district exposed to a good deal of the force, tides and winds of the Atlantic ocean, as is the case on the south side of the island looking out towards Devil's Island. Here at high tide one may cull raspberries with the water coming over one's boots, pick *Scutellaria* on the same spot, watch the milfoils growing in grand profusion and to a great height—as much as 3 to 4 feet or more. Then we have rock roses, not really littoral plants, everywhere, and at the proper season the margins are decked with masses of purple irises, so that one feels inclined to call the island " a garden of irises," for it is not only on the shore they are to be seen, but all over it. Grasses and sedges dip in the water and seem to enjoy the tide rippling over them. Other plants we find are rose-root, sea pea, sea rocket, sedum, asters, scarlet pimpernel, and the white nightshade, the evening primrose, and many more too numerous to mention. Another peculiarity which I noticed was the comparative poverty of the *Fucaceæ* on the shores, that is of species which find their habitat there. On the shore opposite Lawlor's Island, one meets with a couple or so of varieties of the *Melanophyceæ*. On the side towards the ocean opposite Devil's Island, it is about the same, a stray *Fucus vesiculosus* or *F. serratus* and *Laminaria;* while on the shores looking towards Halifax, practically none are to be seen. Along Meagher's Beach we do find various kinds of *Fucus, Florideæ*, etc., but nearly all these are washed up by the tides; few are settlers. Most shores exposed to the ocean are covered more or less with a sea-flora of a beautiful and varied character. The above flora generally appears to be that of brackish water rather than of the true sea type, or true fresh water one.

So far as the land flora generally is concerned, if I went into it in detail, it would occupy a paper by itself, therefore my remarks will of necessity be brief and general. Ferns are

numerous, but considering the nature of the island, a greater variety would have been expected, and that is by no means the case. Mosses are few in variety also, while among the *Equisetaceæ* there are several species. The *Coniferæ* are much as on the mainland, though the hemlock is very rare, and I found it only in one spot on the island.

Looking now for a moment on the Phanerogames of the island, it is curious to note the immense numbers of beautiful violets, and a contrasting absence of their little allies, the wild pansies. I saw but one specimen of the *Hypercineæ*, which is peculiar, as they are very common on the mainland.

The island evidently is a veritable garden, in the season, for raspberries, and this brings me to suggest that it appears to me that McNab's Island might easily be converted to some good use as a spot wherein to grow various crops for economic purposes. Take, for instance, raspberries· the island is well suited for their production; they were very plentiful and of good size this last summer, wild as they are. With a little attention what quantities could be placed on the market in Halifax; there would be little or almost no train or transport rates to cut down the producer's results. Again, from the quantities or irises growing on it, the island is evidently well suited for the growing of them. Would it not be possible to manufacture a cheap and beautiful violet ink, stain, or dye from their rich, velvet perianths? I obtained some good purple writing fluid by a process of extraction from some this last summer, which had the property of darkening on exporsure to sun and rain. I had not time to complete my experiments, however, and the effect of time on the ink on paper can only be judged by how it will look in a year or two's time, and under various conditions of climate, etc., so that I do not intend to make public any results for the present.

Strawberries and blueberries run wild, and what I said about raspberries applies equally to the former. I think the island would also yield grasses for baskets, mats and such like

contrivances, though probably not in the same quantities as might be obtained easier from elsewhere.

The fungi of the island are very numerous and varied. Seldom, if ever, have I seen, certainly not in colour, so many *Basidiomycetes* and *Gastromycetes*: they are beautiful, too, in many instances.

Lichens also are abundant, but with neither of these did I have much to do. What notice I did take of the mushrooms will be referred to in my notes at the end of this paper.

These few general observations are all I wish to offer on the flora generally. I have looked at it from my own point of view, and though probably I have told you nothing new, possibly I have suggested a new light in which to consider it.

This brings me to Part II. of my subject, in which I deal with work specially done in one or two orders. The results may not appear large, but only a few plants can be dealt with carefully in a season. The work done is, as in a previous paper I read before the Institute a couple of years ago, mainly on variation.

Part II.—Work in Special Orders.

Primulaceæ.

Trientalis Americana. Star flower.—One of your commonest spring flowers. 500 specimens at least examined, and on that data results given. Variations in calyx and corolla practically none. In a few specimens one sepal was normally absent. It was in the stamens the variations occurred. In 77 specimens I found 7 stamens in each; in 167 specimens I found 8 stamens in each; in 205 specimens I found 6 stamens in each; and this latter number seems to be the most usual number of stamens present. In 17 specimens I found 5 stamens in each; in 34 specimens I found 4 stamens in each. It is curious to

notice, however, that while you had seven stamens present, often with eight petals; in the case of those with eight stamens the reverse did not hold good. Nearly always when eight stamens were present, eight petals and eight sepals were. Those in which the stamens were below seven, had petals and sepals usually normal, and no corresponding decrease in numbers.

Oxalidaceæ.

Oxalis acetosella. White wood-sorrel.—The number of specimens examined ran into hundreds, but I have lost the exact number. On going through a very large number I found so very little variation, so directed my attention to the descriptions of this plant in floras and compared them with what I noticed for myself, and I think that a modification of those descriptions is desirable, for they do not appear to be full enough or accurate enough in some respects, judging from the results I have obtained after examining at least four hundred or more plants.

The following is the flora's description:—Low herbs with an acid juice and alternate compound leaves, the three leaves obcordate. and drooping in the evening; flowers long, heterogonus; sepals, obtuse; petals, pink, rarely white, veined with deep pink; capsule, subglobose, glabrous; seeds, ovoid, longitudinally grooved.

It is the petals which need a modified description:—Calyx and corolla regular. Petals, unequally divided apex, or as an alternate description, are unequally cordate. Petals may be white, but more usually they are tinted with purplish-pink, due to the ramifications of veins. The veins are of a darker purple-pink than are the petals, usually seven to eight in number, never more on each petal; they start from an orange-yellow corona situated close to the base of each petal.

The remaining description of the flower is an ample one, and does not appear to require to be changed.

Rubiaceæ.

Houstonia cærulea. Bluets.—Quite one of the commonest earlier flowers of the season. 1500 specimens examined, mainly collected on McNab's Island, but some on the mainland in this instance.

There is not much variation in the outer whorls of the flower; flowers with six instead of four petals were met with in a couple of dozen instances, and four or five had as many as seven.

The one great variation I noticed was seen in the length of the style and the number of the stigmas. In the floras, the flower is described as having one style and two stigmas. Now I have found a heterogony of styles in these flowers. One variety has a long style with two stigmas; the second variety has a short style and most usually one stigma. The former I hold to be the one usually described in our books on flora.

The latter I have ventured to distinguish from it by giving it a new name—*Houstonia cærulea var. Piersii*—after your esteemed secretary, Mr. H. Piers, who has aided me in so many ways in this kind of work.

The description, therefore, of the style in this new variety may be said to be as follows:—*Style*—Short, not longer than three-quarters, at most, of the length of the corolla tube. *Stigma*—Single nearly always, but two may be present which are partially united half way up their dorsal aspects.

This new variety I have found is based on the fact that practically one-third of the flowers examined presented these variations. They arise, too, not quite irregularly, for tufts of flowers occur in which all the flowers consist of one or other variety quite separate from those large patches where both kinds may be found indiscriminately.

Iridaceæ.

Iris versicolor. Blue flag.—Subject to little variation. 250 examined. The variations occurred in the flat, petaloid, arching stigmas. In 160, the stigmas possessed two irregular lobes at the apex, which may be considered to be what usually happens; 66 specimens had three lobes; 20 specimens had but one lobe. In four specimens I found one stigma absent, and in these the corresponding stamen was also absent.

Sisyrinchium angustifolium. Blue-eyed grass.—300 specimens examined. I have practically nothing new to add to what I said about this flower in a paper read before this society two years ago. I have not examined so many specimens of this plant this year as I did then, but the results work out the same. There was but one new feature I noticed, and that occurred only in six or eight specimens—it was the presence of little wings on the divisions of the perianth, one on each side.

A question was asked me at the time I read my last paper, which then I could not reply to. I now wish to say the cotyledons have nothing whatever to do with the variations observed; rather it is, as in *Iris versicolor* as well, a selective effort on the part of the flower to increase its surface area to attract certain insects more frequently and suitably, and it depends, I think, on that instinctive faculty, unconscious perhaps in a sense, which I believe animals and plants possess in common, though in varying degree, to reproduce more and more of their kind, even to the detriment of others, if not obtainable otherwise.

Caprifoliaceæ.

Linnæa borealis. Twin flower.—400 specimens examined. No variations worth noting were seen. This flower is one of the most regular plants I have ever examined, and its beauty is only enhanced by its modesty.

Ericaceæ.

Moneses uniflora. One-flowered pyrola.—This peculiar flower, which is the last I have to offer any special notes on, appealed to me much, on account of its prominent anthers, and the apparent want of conformity in the arrangement of its stamens; so much so, that I looked up different floras to see if I could find out what was the most usual arrangement of the whorl. I could not find anything on this subject, so I have undertaken to try and determine what is the most usual arrangement, and in this case, since I have a number of figures to deal with, I will say only that over 1,000 specimens were examined, and the following are the conclusions I arrived at:—(1) that the stamens are in one whorl; (2) the corolla may be complete or incomplete—that is, with five petals or less.

Considering now the flowers from the view that the stamens are ten or less, I want you to look at them as *regular* or *irregular*. Let us first consider the regular flowers:—

(*a*) Regular flowers, with corolla complete. By far the larger majority have the following arrangement of stamens in the whorl, 3, 2, 2, 2, 1. The next commonest is a variation on this, 3, 2, 2, 1, 2. Then come, some little way behind, another arrangement—3, 1, 2, 3, 1, and its variant, 3, 1, 3, 2, 1. Then in order we get 2, 2, 2, 2, 2, and far behind, and in only a few instances, comparatively speaking, 3, 2, 1, 1, 2, 1; 3, 3, 3, 1; 3, 1, 3, 1, 1, 2.

(*b*) Regular flowers with incomplete corolla.—The above arrangements hold good because only one or two flowers were met with in which the corolla was incomplete, and they possessed only four petals.

Let us now consider the irregular flowers:—

(*c*) Irregular flowers with corolla complete.—The usual arrangement was for one of the last pairs of stamens to be absent, if we consider the arrangement to be 3, 2, 2, 2, 1—

thus we get 3, 2, 2, 1, 1. Nine stamens, instead of ten. Next come those with only seven, and then those with eight.

(*d*) Irregular flowers with corolla incomplete.—The usual arrangement is one of eight stamens to four petals—2, 2, 1, 2, 1. Speaking generally, there is much variation in the arrangements among the irregular flowers, the following being the commonest:—

3, 2, 2, 1, 1.	9 stamens in the whorl.
3, 2, 2, 2.	
3, 2, 1, 2, 1.	
2, 2, 2, 1, 1, 1.	
3, 1, 2, 3.	
2, 2, 2, 2, 1.	
3, 2, 2, 1.	8 stamens in the whorl.
3, 1, 1, 2, 1.	
3, 2, 1, 2.	
2, 2, 1, 2, 1.	
2, 2, 2, 1.	7 stamens in the whorl.
3, 2, 2.	
3, 1, 1, 1.	6 stamens in the whorl.

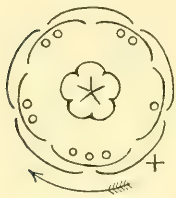
No other variants of any consequence noticed, so that these may be held to be the principal arrangements and numbers of stamens in the flowers.

In the irregular flowers with incomplete corollas, I wish to point out that the numbers of the petals present in the corolla weee usually four or five, and the sepals were decreased in a similar ratio. The carpellary leaves also were decreased in much the same manner.

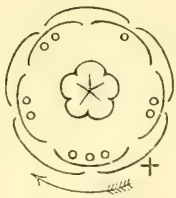
Having given the conclusions obtained, it will be necessary to show you practically how these results have been got at, how I started from a certain part of the whorl and went round it. Take the much more usual arrangement, 3, 2, 2, 2, 1. I always began with a three which I presumed to be on the side nearest to me, and passed round the whorl from right to left;

if I went the reverse way I would only get the above result reversed; but in all cases where three's were present I started to work from that number.

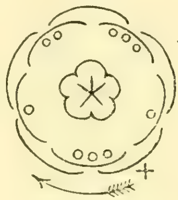
Look at these floral diagrams of flowers of the regular type with complete corollas. I passed round in the direction of the arrows from the spot marked by an x opposite a three.



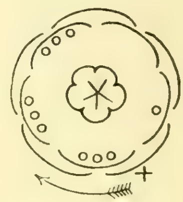
3, 2, 2, 2, 1.
Fig. I.



3, 2, 2, 1, 2.
Fig. II.



3, 1, 2, 3, 1.
Fig. III.



3, 3, 3, 1.
Fig. IV.

Of course it was only by observation for a while previous to systematically proceeding, that I found the most suitable spot to start from. I did the same when a two came first.

While doing this special work, one or two other peculiarities were sometimes observed in the stigmas.

The stigma is usually described in books on flora as "large and peltate, with five narrow, acute, radiating lobes." In a certain number I noticed that the lobes were only four in number, and in about a dozen or more, the stigma itself as a whole assumed a claw-shaped form like that of a bird, and was sessile.

In conclusion, briefly reviewing the results of the staminal arrangements, let me say that in nearly half the specimens examined, 3, 2, 2, 2, 1 was the formula, and consequently it is the normal arrangement of the ten stamens present. Then came its variant, and the other formulæ make up the remainder.

Part III.—Narcotisation of Plants.

This part of my paper consists of a few experiments made on wet days when outdoor work could not be well done. The plants used were mostly common ones found on the island, and chloroform was the narcotic used. In many cases several experiments were done with the same kind of plant. I do not claim that the results gained are as accurate as they might be, but looking over some works on physiology of plants, I can say this, that certainly some of them are borne out as correct to a great extent; and remember, I was in camp with only rough contrivances to work with. I am satisfied myself with my results, but in any case I hope it may prove interesting to you to hear them. I take the flowers used in no special order; will say what I did, briefly, and sum up results afterwards.

Moneses uniflora.—Specimens dry. Placed in lethal chamber entirely; that is, with only the air in the chamber. Narcotic given. Flowers changed in colour to light brown in two minutes; corolla, brown; anthers, untouched; carpels blackish, styles and stigma untouched. In half an hour all parts of flower dark brown.

Trientalis americana.—Specimens dry. Placed in chamber as in former case exactly. Little change in half an hour; flowers just a little flaccid.

Oxalis acetosella.—Specimen dry, and put into chamber as in previous specimens. Almost at once the leaves fell down and drooped; the petals of the flower curled back, instead of in, as in sleep, in ten minutes. The flower became limp, but colour remained unchanged. The leaves later opened again, but remained flaccid. Compare these results with normal sleep.

Specimens moistened with water and placed in the chamber. Effects less, leaves affected the most. Flowers became limp, but colour unchanged in ten minutes.

Moss.—Quite unaffected in ten minutes, or half an hour.

Cypripedium acaule.—Specimens dry when placed in chamber. Affected in five minutes; the other greenish lobes, the perianth, becoming discoloured and droop. Other effects proceed very slowly indeed, it taking two to three hours to bring results. Curious to say, the flowers transpired more or less under the influence of the narcotic, and the final result is difficult to obtain,—complete anæsthesia as it were.

Hieracium canadenis.—Specimens dry. Flowers began to be influenced in 15 minutes. Completely under influence in 20 minutes. Stems below the head absolutely limp, so that the flower head hung sharply down. The strap-like rays became dark yellow, but not closed as in sleep; they remained one-half to one-third open, and slightly curled on themselves. Another curious effect was observed in this plant, that when a specimen was placed dry, and just as it had been plucked, and not under the influence of the narcotic, in a chamber free from narcotic, but in which also was a narcotised orchid, this latter plant seemed to affect the hawkweed, which became drowsy and closed as in sleep, more or less.

Potentilla tormentosa.—Specimens used dry. In ten minutes the leaves were affected. The flowers closed in twenty minutes.

Drosera rotundifolia.—Specimens dry. In ten minutes leaves became flaccid and curled backwards. The tentacles became irregularly twisted and crossed. Recovery from influence took place if flower was placed in soil after a time, which was most unusual in those flowers I experimented upon.

Specimens moistened or wet. Flowers more tardy about coming under influence of the narcotic. At the end of fifteen minutes, slight discoloration, but no closing of flowers or drooping of the tentacles for fifteen minutes more, and then it was incomplete. Leaves behaved as in previous experiments. Here again the results differed from those obtained when ordinary stimuli are applied.

Onoclea sensibilis.—Fronds drooped in ten minutes. Pinnæ curled back.

Chrysanthemum leucanthemum.—Specimens dry. Heads began to droop in twenty minutes, when the root is present. Heads without root drooped and closed, leaves darkened and became limp in eight minutes.

Head with roots present, roots in lethal chamber completely, but head and leaves outside chamber in fresh air. Little affected. Leaves became slightly discolored, and flower just began to close in two hours.

Cornus canadensis.—Specimens dry. Very resistant. No effects in one hour. In one and a-half hours leaves just began to turn yellowish. In two hours quite yellow. These flowers sometimes transpire slightly under the influence of narcotic.

Trifolium pratense.—Specimens dry. Leaves affected in ten minutes, becoming nearly black, and limp. The flowers changed to purple from red in 28 minutes. Scent disappeared first and early, in five minutes. Changes completed in one hour.

Prunella vulgaris.—Specimens dry. Very rapidly affected. Flowers turned brown and became limp in five minutes or less. Leaves darkened. Results same, whether roots were present or not.

Iris versicolor.—Specimens dry. Flowers drooped in 15 minutes. Transpired slightly.

Sedum acris.—Affected in five minutes.

Sarracenia purpurea.—Specimens slightly moist and wet. Flowers affected in fifteen minutes, drooping. Discoloration slight. Leaves not affected for a longer time.

Ranunculus acris.—Specimens dry. Heads drooped and became a darker yellow in twenty minutes; leaves changed to a deep olive colour, and became limp in ten minutes. In specimens in which the roots were in lethal chamber and heads in fresh air, leaves closed in ten minutes, but were not discolored. The flowers were unaffected for a long time.

Taraxacum officinale.—Specimens dry. Flowers closed in ten minutes; closing complete.

Stellaria media and *Cerastium arvense.*—Specimens dry. In 25 minutes flowers began to droop and close slightly; leaves were unaffected. In 30 minutes flowers were closed completely. No discoloration of flowers or leaves.

Fragaria virginiana.—Specimens dry. Resistant. Only semi-narcotised in one hour.

Arctostaphylos uva-ursi.—Specimens dry. Influenced only slowly. Leaves discolored, but not limp, and flowers semi-closed in one hour. Specimens moistened, results the same.

Trifolium repens.—Specimens dry. Scent disappeared in seven minutes. Leaves drooped in ten minutes and became brown. In one hour the flower is seen to have its florets mostly lying with their apices pointed outwards instead of upwards as when fresh.

Habenaria lacera.—Specimens dry. Flaccid generally in ten minutes. Flowers brown in 15 minutes.—Specimens wet. Flaccid generally in 15 minutes. Flowers brown in half an hour.

Chrysanthemum leucanthemum and *Oxalis acetosella* were both placed with their leaves and flowers in air, but with their roots in chloroform fluid. In the case of the former, the chloroform seemed to act as a stimulant; the flowers thrived in it for 24 hours. In the latter, however, the leaves fell in ten minutes, and the flower drooped soon after. These were the only plants experimented with in this way.

The conclusions drawn from these few rough experiments were as follows, but they must not be considered conclusive, but rather as incentives to others to more accurately work up this physiological section:—

Conclusion I., is that some flowers are more sensitive to the influence of the narcotic than others, and in various degrees and times, even when removed from its direct influence.

II.—It is through the leaves, flowers and stem that this influence acts, more than by the roots, for often when applied to the latter, the results take longer to arrive at. Sometimes it even appears to act as a stimulant when applied directly to the roots.

III.—Colour is always affected practically, and purple flowers and leaves seem to be more influenced than a good many lighter ones.

IV.—In many instances, the results obtained are more or less the opposite to those seen when natural influences, such as wind, rain, heat or cold are applied. They are also the reverse of natural sleep.

V.—Some flowers transpire under the influence of a narcotic, and those which do most are the hardest to be affected.

VI.—Though I have not mentioned it in my experiments, flowers slightly under the influence of a narcotic may recover if removed from it; those deeply under it rarely, if ever, do.

VII.—Cell contents become altered. Granules may become disorganized or swell.

The practical reasons for my experiments are the same as so many others have done them for, and resolve themselves into three questions—What are the best flowers and plants for a town or house in and around which noxious chemical products are formed? Which are those least likely to be affected by soot, dust, harmful vapours, etc., containing narcotising elements? How may we still keep our towns and parks beautiful under such conditions? These simple experiments with wild flowers throw little light, I grant, on such things, but possibly one or two ideas may be gained, although similar experiments accurately conducted have often been done, which may be the stepping stones to greater efforts on the part of those who are interested in the beautifying of their native city, and who can teach those

in slum-land the simple methods of keeping in the way of thriving, their few window plants, possibly their only knowledge of the country beyond the city's outskirts.

PART IV.—OCCASIONAL NOTES ON FLORA OF McNAB'S ISLAND.

Early fruit.—A ripe blackberry was found by me and eaten on July 20th, before I saw ripe raspberries.

Instances of similarity in colour and shape between various plants.—A couple of strawberry flowers which were found in different spots, but in both cases in the middle of a patch of *Oxalis acetosella*, had taken on the purple-white or pink colour of this latter flower, and both had only four petals. At a distance they were indistinguishable from the *Oxalis,* and it was only by chance, when picking these flowers, I noticed those of the strawberry.

Linnæa borealis I found quite white in the middle of bunchberries.

The *Basidiomycetes*, or mushrooms and toadstools of the island also in many instances seem to take on the colour of plants near which they grow; whether it is due to assimilation of colouring matter from such plants which can be quickly elaborated by these fast-growing fungi, or what is its special use I cannot say. For protection it cannot be; for fertilisation purposes it is very nearly unnecessary. As instances of what I mean I give the following, which I saw myself:

I saw a concolvulus flower trailing close to the ground; beside it was a toadstool, purple-red in colour, with a dirty white mottling as well, and a slight dimple on the upper surface of the pileus. The convolvulus flower was almost exactly the same in appearance, the white of the flower being dulled also. Moreover the opening of the tube of the corolla was so closed that one would say it was more like a fissure or dimple. At the first glance I thought both flower and toadstool were both the latter.

Another instance: I was passing some bunches or iris leaves, the veins of which are usually purplish in colour. Close to, in fact touching, them was a stump of what looked to be the remains of another bunch of leaves. I knocked it with my foot and found it was the stipe and partially unopened cap of a toadstool. The purple of the latter was exactly the same as the former.

So have I seen orange-yellow coloured ones growing close to the yellow loosestrife, bright red ones among the red bunch-berries, perfectly white ones near the Indian pipe, and so alike were they that they could not be distinguished till you were right upon them. Little, tiny white specks of toadstools among the moss, near where other little white flowers abound; variegated near where variation in many colours abound.

Of course many occur in situations quite independent of such conditions, but a certain number do find their habitat according to the above, and many other instances I have not noted.

A Catalogue of the Birds of Prince Edward Island.—By John MacSwain, Charlottetown, P. E. I.

(Read 13th November, 1905; revised to 1907.)

This catalogue of the birds of Prince Edward Island has been compiled chiefly from field notes, beginning in 1895 and continued to the present time. It contains the names of two hundred and three birds seen by the writer during this period of thirteen years; and a supplementary list of thirteen additional birds stated to occur in Prince Edward Island in the "Catalogue of Canadian Birds" by Prof. Macoun. There is a similar list of four species from "Birds of Prince Edward Island," by the late Mr. Francis Bain.

There are few works which make special reference to the birds of the Island. The most important is the interestingly written book of Mr. Bain just mentioned, which describes one hundred and fifty-two birds. It was published in 1891. Besides this, Mr. Bain, in his "Natural History of Prince Edward Island," devoted a section to the birds found here, and he wrote two or more magazine articles on the same subject. "Progress and Prospects of Prince Edward Island," 1861, by C. Birch Bagster, contains a list of forty-six birds. "A Manual of the Geography and Natural and Civil History of Prince Edward Island," 1861, by Rev. D. Sutherland, has a chapter on birds. These, with some articles which have appeared in the Island newspapers and "The Prince Edward Island Magazine," make up the ornithological literature of Prince Edward Island. Some tables on migration are appended to the catalogue.

The nomenclature is that of the American Ornithologists' Union "Check-List," and the numbers in parentheses refer to that work.

ORDER PYGOPODES.

FAMILY PODICIPIDÆ.

1 (3). *Colymbus auritus* Linn. Horned Grebe.—Have seen one mounted specimen.

2 (6). *Podilymbus podiceps* (Linn.). Pied-billed Grebe. —Rare.

FAMILY URINATORIDÆ.

3 (7). *Urinator imber* (Gunn.). Loon.—Not common, but frequently seen during summer. Breeds.

4 (11). *Urinator lumme* (Gunn.). Red-throated Loon. —Not seen as often as the preceding.

FAMILY ALCIDÆ.

5 (27). *Cepphus grylle* (Linn.). Black Guillemot.—Captured occasionally. All that I have seen were in the mottled plumage. Breeds.

6 (30). *Uria troile* (Linn.). Murre.—Rarer than the Black Guillemot.

7 (34). *Alle alle* (Linn.). Dovekie; Little Auk.—More frequently seen than either the Black or Common Guillemot.

ORDER LONGIPENNES.

FAMILY STERCORARIIDÆ.

8 (37). *Stercorarius parasiticus* (Linn.). Parasitic Jaeger. —Have seen one specimen only.

9 (40). *Rissa tridactyla* (Linn.). Kittiwake.—Common during summer.

10 (42). *Larus glaucus* Brunn. Glaucus Gull; Ice Gull. —Often seen in the autumn.

11 (45). *Larus kumlieni* Brewst. Kumlien's Gull.—Taken at Covehead, Oct. 7, 1905, and examined soon after it was taken to the taxidermist. It is now in the museum of the Academy, Truro, N. S. There are some ashy areas on some of the primaries of this specimen.

12 (47). *Larus marinus* Linn. Great Black-backed Gull.—Quite common spring and autumn.

13 (51). *Larus argentatus smithsonianus* Coues. American Herring Gull.—Common.

14 (54). *Larus delawarensis* Ord. Ring-billed Gull. —Have seen one only.

15 (60). *Larus philadelphia* (Ord.). Bonaparte's Gull. —Common.

16 (64). *Sterna tschegrava* Lepech. Caspian Tern.—One was shot at Tracadie Bay, May 13th, 1905.

17 (70). *Sterna hirundo* Linn. Common Tern.—Commonest of the terns seen here.

18 (71). *Sterna paradisæa* Brunn. Arctic Tern.—Not common.

ORDER TUBINARES.

FAMILY PROCELLARIIDÆ.

19 (94). *Puffinus filiginosus* (Strickland). Sooty Shearwater.—Very rare. One was mounted by Calder in 1904.

20 (104). *Procellaria pelagica* Linn. Stormy Petrel.—One was stuffed by Calder and sent to the museum of the Truro Academy in the autumn of 1905. Two were blown ashore on the north coast of the Island during the great November gales of 1906, and were brought to Mr. Calder.

21 (109). *Oceanites oceanicus* (Kuhl.). Wilson's Petrel. —Occasionally found on north coast of the Island.

ORDER STEGANOPODES.

FAMILY SULIDÆ.

22 (117). *Sula bassana* (Linn.). Gannet.—Not uncommon. Saw one on St. Peter's Bay, July 7th, 1905.

Family PHALACROCORACIDÆ.

23 (119). *Phalacrocorax carbo* (Linn.). Cormorant.—A few may be seen every summer.

24 (120). *Phalacrocorax dilophus* (Swainson). Double-crested Cormorant.—Rarer than the preceding.

Order ANSERES.

Family ANATIDÆ.

25 (129). *Merganser americanus* (Cass.). American Merganser ; Goosander.—Occasionally seen.

26 (130). *Merganser serrator* (Linn.).—Red-breasted Merganser. Common.

27 (132). *Anas boschas* Linn. Mallard.—Rare.

28. (133). *Anas obscura* Gmelin. Black Duck.—The commonest of our ducks. Breeds here.

29 (135). *Anas strepera* Linn. Gadwell.—Very rare.

30 (139). *Anas carolinensis* Gmelin. Green-winged Teal.—Frequently seen.

31 (140). *Anas discors* Linn. Blue-winged Teal.—Rarer than the Green-winged Teal.

32 (143). *Dafila acuta* (Linn.). Pintail.—Not uncommon.

33 (144). *Aix sponsa* (Linn.). Wood Duck.—Very rare indeed. Have seen none for some years. Saw one in 1893.

34 (148). *Aythya marila nearctica* Stejn.—American Scaup Duck. A rare spring and fall migrant.

35 (149). *Aythya affinis* (Eyt.). Lesser Scaup Duck.—No commoner than the larger scaup.

36 (151). *Glaucionetta clangula americana* (Bonap.). American Golden-eye.—Common in autumn. Breeds.

37 (152). *Glaucionetta islandica* (Gmel.). Barrow's Golden-eye.—Have seen two only. These were shot at St. Peter's Bay in the spring of 1904.

38 (153). *Charitonetta albeola* (Linn.). Bufflehead.—Rarely seen in early spring.

39 (154). *Clangula hyemalis* (Linn.). Old Squaw; Long-tailed Duck: Cockawie.—Often seen with Golden-eyes in early spring.

40 (160). *Somateria dresseri* Sharpe. American Eider.—I have seen but two specimens; mounted by Mr. Calder.

41 (163). *Oidemia americana* Swainson. American Scoter.—Rare.

42 (165). *Oidemia deglandi* Bonap. White-winged Scoter.—Sometimes seen on the northern coast.

43 (166). *Oidemia perspicillata* (Linn.). Surf Scoter; Sea Coot.—Seen in autumn.

44 (167). *Erismatura rubida* (Wils.). Ruddy Duck.—One mounted specimen seen, Oct. 14th, 1904. Very rare.

45 (171*a*) *Anser albifrons gambeli* (Hartl.). American White-fronted Goose.—On Oct. 21st saw a young goose, afterwards mounted, which corresponded in size and color with the description of the young of this species.

46 (172). *Branta canadensis* (Linn.). Canada Goose; Wild Goose.—Common during migration, spring and autumn.

47 (172*a*). *Branta canadensis hutchinsii* (Swains. & Rich.). Hutchins's Goose.—Occasionally with flocks of *B. canadensis*.

48 (173). *Branta bernicla* (Linn.). Brant.—Arrives in large flocks soon after the breaking up of the ice in spring and leave for the north early in June.

49 (180). *Olor columbianus* (Ord.). Whistling Swan.—One was shot at Wheatley River, October, 1885. This specimen was mounted and is now in the possession of Judge McDonald.

Order HERODIONES.

Family ARDEIDÆ.

50 (190). *Botaurus lentiginosus* (Montag.). American Bittern.—Not common.

51 (194). *Ardea herodias* Linn. Great Blue Heron — Quite common. Seen in numbers at ebb-tide along the borders of rivers. Breeds.

52 (202). *Nycticorax nycticorax nævius* (Bodd.). Black-crowned Night Heron.—Very rare. A young specimen was shot in the marshes at Mount Stewart by a Charlottetwn sportsman, and examined by me at Mr. Calder's.

Order PALUDICOLÆ.

Family GRUIDÆ.

53 (205). *Grus canadensis* (Linn.). Little Brown Crane. —Accidental. A young specimen was shot at Earnscliffe, Oct. 23, 1905. I examined it at Mr. Calder's. Length 30.50 in., wing 18 in., bill 2.75 in. Plumage dark gray, tipped with light brown or bronze: feathers of head brown or chestnut. On May 22, 1899, I saw a mounted specimen of this bird exhibited in Mr. Watson's drugstore.

Family RALLIDÆ.

54 (212). *Rallus virginianus* Linn. Virginia Rail.—Saw a stuffed specimen which was collected by Mr. W. Earle at Tignish, where they are occasionally seen. Mr. Earle also shot one at Belle River, and it is now in his collection.

55 (214). *Porzana carolina* (Linn.). Sora; Carolina Rail.—Collected by Mr. Earle at Tignish, and now in his possession. Two were shot at Wisener's Mills on Oct. 4, 1906, by Mr. Frank E. Johnson of Yonkers, N. Y.

56 (221). *Fulica americana* Gmel. American Coot.—Not common, but is occasionally seen in the low grounds bordering

streams. A specimen was taken and mounted by Bryenton, who sold it afterwards to Calder. Though rare, the Coot, or "Mud-hen" as it is called, is well known to sportsmen here.

Order LIMICOLÆ.

Family SCOLOPACIDÆ.

57 (228). *Philohela minor* (Gmel.). American Woodcock.—Once common, but now rare. It arrives here in early spring, sometimes in March. Soon afterwards it builds its nest and rears its young.

58 (230). *Gallinago delicata* (Ord.). Wilson's Snipe.—Scarcely exceeds the Woodcock in number. Breeds.

59 (234). *Tringa canutus* Linn. Robin Snipe.—Shot at Alexandra by J. H. Judson, 24th September, 1905, and mounted by Calder.

60 (235). *Tringa maritima* Brunn. Purple Sandpiper.—Saw one at Calder's, which was shot at St. Peter's Island, Feb. 6th, 1901.

61 (239). *Tringa maculata* Viell. Pectoral Sandpiper; "Jack Snipe."—Four of these birds were in the market, Charlottetown, on Sept. 27, 1907. I do not remember to have noted this species before.

62 (240). *Tringa fuscicollis* Vieill. White-rumped Sandpiper.—A few spring and autumn migrants.

63 (242). *Tringa minutilla* Vieill. Least Sandpiper.—Common.

64 (246). *Ereunetes pusillus* (Linn.). Semipalmated Sandpiper.—Common during the summer.

65 (248). *Calidris arenaria* (Linn.). Sanderling.—Common migrant.

66 (251). *Limosa hæmastica* (Linn.). Hudsonian Godwit.—This species has become very rare. One specimen was taken at Alberton and forwarded to Mr. Earle, who handed it

to Mr. Calder to be mounted. I have seen but two of these birds.

67 (254). *Totanus melanoleucus* (Gmel.). Greater Yellow-legs.—Often seen along the sea beach in spring and autumn.

68 (255). *Totanus flavipes* (Gmel.). Yellow-legs.—Rather rarer than the Greater Yellow-legs.

69 (256). *Totanus solitarius* (Wilson). Solitary Sandpiper.—A few pass the summer and rear their young on the borders of inland ponds.

70 (258). *Symphemia semipalmata* (Gmel.). Willet.—Rare.

71 (263). *Actitis macularia* (Linn.). Spotted Sandpiper.—Common. Nests in border of woods or sometimes in a grain field. Breeds.

72 (264). *Numenius longirostris* Wils. Long-billed Curlew.—Rare.

73 (265). *Numenius hudsonicus* Lath. Hudsonian Curlew.—A not uncommon summer visitor.

74 (266). *Numenius borealis* (Forst.). Eskimo Curlew.—Commonest of the three curlews.

FAMILY CHARADRIIDÆ.

75 (270). *Charadrius squatarola* (Linn.). Black-bellied Plover; Beetle-head.—Seen in flocks of the Golden Plover.

76 (272). *Charadrius dominicus* Mull. American Golden Plover. Once quite common; now rare.

77 (273). *Ægialitis vocifera* (Linn.). Kildeer.—Very rare.

78 (274). *Ægialitis semipalmata* Bonap. Semipalmated Plover; Ring-neck Plover.—Not uncommon.

79 (277). *Ægialitis meloda* (Ord.). Piping Plover.—Common. Saw four on Souris beach, July 6th, 1905. Breeds.

FAMILY APHRIZIDÆ.

80 (283). *Arenaria interpres* (Linn.). Turnstone.—Not uncommon.

ORDER GALLINÆ.

FAMILY TETRAONIDÆ.

81 (298). *Dendragapus canadensis* (Linn.). Canada Grouse. —I have never seen the Canada Grouse anywhere here. Some elderly sportsmen who claim to know the difference between this and the Ruffed Grouse, state that it was not uncommon not many years ago. Now it is probably extinct in Prince Edward Island.

82 (300*a*). *Bonasa umbellus togata* (Linn.). Canadian Ruffed Grouse.—Rare a few years ago, but lately, owing to a better game law, it is increasing in number. Breeds.

ORDER COLUMBÆ.

FAMILY COLUMBIDÆ

83 (315). *Ectopistes migratorius* (Linn.). Passenger Pigeon. —At one time seen in large flocks; the last seen was in 1857.

84 (316). *Zenaidura macroura* (Linn.). Mourning Dove. —Taken at Alexandra, Sept. 22, 1905, by F. H. Judson, and mounted by Calder.

ORDER RAPTORES.

FAMILY FALCONIDÆ.

85 (331). *Circus hudsonius* (Linn.). Marsh Hawk.— Common. Breeds.

86 (332). *Accipter velox* (Wils.). Sharp-shinned Hawk.— Not uncommon. Breeds.

87 (333). *Accipiter cooperi* (Bonap.). Cooper's Hawk.— Rare. This and the Sharp-shinned are our most destructive hawks and are usually the raiders of poultry yards.

88 (334). *Accipiter atricapillus* (Wils.). American Goshawk.—An occasional winter visitor.

89 (337). *Buteo borealis* (Gmel.). Red-tailed Hawk.— Common in the more wooded parts of the country where it breeds.

90 (347*a*). *Archibuteo lagopus sancti-johannis* (Gmel.). American Rough-legged Hawk.—Have seen but one winter specimen.

91 (352). *Haliæetus leucocephalus* (Linn.). Bald Eagle; White-headed Eagle.—Very rare visitor. There is a mounted specimen in the hall of the Provincial Building. Three were seen by me about a mile north of Souris on July 5th, 1906.

92 (354*b*). *Falco rusticolus obsoletus* (Ridg.). Black Gyrfalcon.—One was captured near Southport, November 7th, 1904.

93 (356). *Falco peregrinus anatum* (Bonap.). Duck Hawk.—A young specimen was secured at Lowther's Point on October 3, 1906, by Mr. Frank E. Johnson of Yonkers. N. Y.

94 (357). *Falco columbarius* Linn. Pigeon Hawk.—Rare, but found breeding.

95 (360). *Falco sparverius* Linn. American Sparrow Hawk.—Rare. Breeds.

96 (364). *Pandion haliaetus carolinensis* (Gmel.). American Osprey; Fish Hawk.—Not common.

Family BUBONIDÆ.

97 (366). *Asio wilsonianus* (Less.). American Long-eared Owl.—Very rare; one on October 14th, 1904.

98 (367). *Asio accipitrinus* (Pall.). Short-eared Owl.—Commoner than the preceding.

99 (368). *Syrnium nebulosum* (Forst.). Barred Owl.—Though not abundant, it is both a summer and winter resident.

100 (371). *Nyctala tengmalmi richardsoni* (Bonap.). Richardson's Owl.—One was shot in a barn at Alexandra and was brought to Calder to be mounted, December 26, 1905.

101 (372). *Nyctala acadica* (Gmel.). Saw-whet Owl; Acadian Owl.—Resident and not rare. Several specimen were collected near Pownal, 1904.

102 (373). *Megascops asio* (Linn.). Screech Owl. I have seen one only.

103 (375). *Bubo virginianus* (Gmel.). Great Horned Owl.—This and *S. nebulosum* are our commonest owls. Breeds.

104 (375*a*). *Bubo virginianus subarcticus* (Hoy). Western Horned Owl.—One, the only one I have seen, was brought to Calder to be stuffed in February, 1906.

105 (376). *Nyctea nyctea* (Linn.). Snowy Owl.—An irregular winter visitor. A great many were noted in the winter of 1905-6.

106 (377*a*). *Surnia ulula caparoch* (Mull.). American Hawk Owl.—Rare. There are two mounted specimens in the Provincial Building.

ORDER COCCYGES.

FAMILY CUCULIDÆ.

107 (387). *Coccyzus americanus* (Linn.). Yellow-billed Cuckoo.—One was shot by Bryenton at Brackley Point. It is now in the museum of the Natural History Society, Charlottetown.

108 (388). *Coccyzus erythrophthalmus* (Wils.). Black-billed Cuckoo.—Rare.

FAMILY ALCEDINIDÆ.

109 (390). *Ceryle alcyon* (Linn.). Belted Kingfisher.—A common summer resident. Breeds, making its tunnelled nests in river banks.

ORDER PICI.

FAMILY PICIDÆ.

110 (393*a*). *Dryobates villosus leucomelas* (Bodd.). Northern Hairy Woodpecker.—Resident summer and winter. Breeds.

111 (394). *Dryobates pubescens medianus* (Swains.). Downy Woodpecker.—Commoner than the Hairy Woodpecker. Seen at all times in the year. Breeds.

112 (400). *Picoides arcticus* (Swains). Arctic Three-toed Woodpecker.—A rare winter visitor.

113 (401). *Picoides americanus* Brehm. American Three-toed Woodpecker.—Rarer even than the preceding.

114 (402). *Sphyrapicus varius* (Linn.). Yellow-bellied Sapsucker.—Rare: but several were collected in May, 1904.

115 (405*a*). *Ceophlœus pileatus abieticola* Bangs. Northern Pileated Woodpecker.—Becoming rarer as the forests disappear. A mounted specimen is in the Provincial Building.

116 (412*a*). *Colaptes auratus luteus* Bangs. Northern Flicker; Yellow-hammer.—A common summer resident. Breeds.

Order MACROCHIRES.

Family CAPRIMULGIDÆ.

117 (420). *Chordeiles virginianus* (Gmel.). Nighthawk. —Commonly known as the "Mosquito Hawk." A common summer resident. Breeds. Bird on two eggs found on the gravelled roof of Prince Street School, June 15th, 1905.

Family MICROPODIDÆ.

118 (423). *Chætura pelagica* (Linn.). Chimney Swift.—Apparently not so common as they were some years ago. Breeds.

Family TROCHILIDÆ.

119 (428). *Trochilus colubris* (Linn.). Ruby-throated Hummingbird.—A not uncommon summer resident. Breeds.

Order PASSERES.

Family TYRANNIDÆ.

120 (444). *Tyrannus tyrannus* (Linn.). Kingbird.—Common summer resident. Breeds.

121 (456). *Sayornis phœbe* (Lath.). Phœbe.—Rare. Breeds.

122 (459). *Contopus borealis* (Swains.). Olive-sided Flycatcher.—Common. Breeds.

123 (461). *Contopus virens* (Linn.). Wood Pewee.—Not rare. Breeds.

124 (463). *Empidonax flaviventris* Baird. Yellow-bellied Flycatcher.—Very rare; one only seen.

125 (466*a*). *Empidonax pusillus traillii* (Aud.). Traill's Flycatcher.—Very rarely seen.

126 (467). *Empidonax minimus* Baird. Least Fly-catcher.—Occasional.

FAMILY ALAUDIDÆ.

127 (474). *Otocoris alpestris* (Linn.). Horned Lark.—Seen in migration in early spring and autumn. Sometimes with Snow-buntings.

FAMILY CORVIDÆ.

128 (477). *Cyanocitta cristata* (Linn.). Blue Jay.—Common in summer and winter. Breeds.

129 (484). *Perisoreus canadensis* (Linn.). Canada Jay.—Common many years ago, now quite rare. Breeds.

130 (486*a*). *Corvus corax principalis* Ridg. Northern Raven.—Accidental. Two were shot at Montague, March, 1904.

131 (488). *Corvus americanus* Aud. American Crow.—Very common; resident. Not so many remain throughout the winter. Breeds.

FAMILY ICTERIDÆ.

132 (492). *Dolichonyx oryzivorus* (Linn.). Bobolink.—A rare summer visitor.

133 (498). *Agelaius phœniceus phœniceus* (Linn.). Red-winged Blackbird.—Two specimens were seen by Prof. Macoun at Covehead, July, 1888. Two pairs of these birds were in this place, Covehead, in July, 1905. Breeds.

134 (501). *Sturnella magna* (Linn.). Meadow-lark.—Have seen but one specimen, collected by Mr. Earle in Western Prince County, where it is occasionally seen. It is in Mr. Earle's collection.

135 (507). *Icterus galbula* (Linn.). Baltimore Oriole.—One pair was seen by Prof. Macoun near Brackley Point, and a specimen was taken at Tignish.

136 (509). *Scolecophagus carolinensis* (Mull.). Rusty Blackbird.—Not rare. Breeds.

137 (511*b*). *Quiscalus quiscala æneus* (Ridg.). Bronzed Grackle.—Common within the last three years. Nests near the city.

FAMILY FRINGILLIDÆ.

138 (515). *Pinicola enucleator* (Linn.). Pine Grosbeak.—Some winters common ; others, not seen.

139 (517). *Carpodacus purpureus* (Gmel.). Purple Finch.—Common within the last few years. Breeds.

140 (—). *Passer domesticus* (Linn.). European House Sparrow.—A rather too common resident. First seen in Charlottetown in November, 1886. Breeds.

141 (521). *Loxia curvirostra minor* (Brehm). American Crossbill.—Not uncommon.

142 (522). *Loxia leucoptera* Gmel. White-winged Crossbill.—Less frequent than American Crossbill.

143 (528). *Acanthis linaria* (Linn.). Redpoll.—A rare spring visitor.

144 (529). *Spinus tristis* (Linn.). American Goldfinch.—A summer resident. Common for the last few years. Breeds.

145 (533). *Spinus pinus* (Wils.) Pine Siskin; Pine Finch.—Not so common now as they were a few years ago.

146 (534). *Plectrophenax nivalis* (Linn.). Snowflake; Snow Bunting; Snowbird.—Flocks are often seen in late autumn and winter.

147 (540). *Poocætes gramineus* (Gmel.). Vesper Sparrow; Grass Finch.—Local in distribution, not abundant in any locality.

148 (542*a*). *Ammodramus sandwichensis savanna* (Wils.). Savanna Sparrow.—A few may be found in any locality. Breeds.

149 (549*b*). *Ammodramus caudacutus subvirgatus* Dwight. Acadian Sharp-tailed Sparrow.—Rare. A few have been seen on the marshes along the Hillsborough River.

150 (550). *Ammodramus maritimus* (Wils.). Seaside Sparrow.—Very rare.

151 (554). *Zonotrichia leucophrys* (Forst.). White-crowned Sparrow.—Found in a few localities.

152 (558). *Zonotrichia albicollis* (Gmel.). White-throated Sparrow; Kennedy Bird.—A common summer resident. Breeds.

153 (559). *Spizella monticola* (Gmel.). Tree Sparrow.—A few seen during the spring migration.

154 (560). *Spizella socialis* (Wils.). Chipping Sparrow.—Common. A summer resident. Breeds.

155 (563). *Spizella pusilla* (Wils.). Field Sparrow.—I have seen this bird only on three occasions. Breeds.

156 (567). *Junco hyemalis* (Linn.). Junco.—Common. Found everywhere. Breeds.

157 (581). *Melospiza fasciata* (Gmel.). Song Sparrow.—This is our earliest, and next to the Junco, our most abundant sparrow. Breeds.

158 (584). *Melospiza georgiana* (Lath.). Swamp Sparrow.—A rare summer resident. Breeds.

159 (585). *Passerella iliaca* (Merr.). Fox Sparrow.—A few are seen on their way north and south.

160 (587). *Pipilo erythrophthalmus* (Linn.). Towhee; Chewink.—Very rare. Saw a few on Malpeque Road in 1900.

161 (595). *Habia ludoviciana* (Linn.). Rose-breasted Grosbeak.—Uncommon. All that I have seen have been taken near Bradalbane.

162 (604). *Spiza americana* (Gmel.). Dickcissel; Black-throated Bunting.—Very rare. One mounted specimen seen.

Family HIRUNDINIDÆ.

163 (612). *Petrochelidon lunifrons* (Say). Cliff Swallow; Eave Swallow.—Not so common since the advent of the House Sparrow. The latter has in some places taken possession of the nesting places of the swallow. Breeds.

164 (613). *Chelidon erythrogaster* (Bodd.). Barn Swallow.—A common summer resident, breeding chiefly in barns.

165 (614). *Tachycineta bicolor* (Vieill.). Tree Swallow.—Not so common as our other species of swallows. Arrives about the same time. Breeds.

166 (616). *Clivicola riparia* (Linn.). Bank Swallow.—Nests in high banks of St. Peter's Island and other suitable places along the coast.

Family AMPELIDÆ.

167 (619). *Ampelus cedrorum* (Vieill.). Cedar Waxwing.—A not uncommon summer resident; nests in August.

Family LANIIDÆ.

168 (621). *Lanius borealis* Vieill. Northern Shrike; Butcher-bird.—A rare winter visitor.

169 (622). *Lanius ludovicianus* (Linn.). Loggerhead Shrike.—Rarer even than the preceding.

Family VIREONIDÆ.

170 (624). *Vireo olivaceus* (Linn.). Red-eyed Vireo.—Not common. Breeds.

171 (627). *Vireo gilvus* (Vieill.). Warbling Vireo.—In spring small flocks are sometimes seen on their way northward. The specimen I examined was shot by Bryenton at Brackley Point.

172 (631). *Vireo flavifrons* Vieill. Yellow-breasted Vireo.—More numerous than the Red or White-eyed Vireo.

173 (631). *Vireo noveboracensis* Gmel. White-eyed Vireo.—Not common.

Family MNIOTILTIDÆ.

174 (636). *Mniotilta varia* (Linn.). Black and White Warbler.—Rare.

175 (642). *Helminthophila chrysoptera* (Linn.). Golden-winged Warbler.—One was seen on June 5th, 1897.

176 (645). *Helminthophila ruficapilla* (Wils.). Nashville Warbler,—Not common. Have seen two at Mermaid, south of Hillsboro.

177 (647). *Helminthophila peregrina* (Wils.). Tennessee Warbler.—Saw three of these warblers in June, 1900. Have seen no others.

178 (648). *Compsothlypis americana* (Linn.). Parula Warbler.—Not common.

179 (650). *Dendroica tigrina* (Gmel.). Cape May Warbler. —One only has come under my notice. It was in a spruce grove near Charlottetown, September 2nd, 1899.

180 (652). *Dendroica æstiva* (Gmel.). Yellow Warbler. — Common; often builds its nest in a lilac bush in the city.

181 (655). *Dendroica coronata* (Linn.). Myrtle Warbler. —Common. The first to arrive and the most numerous of our warblers. Breeds.

182 (657). *Dendroica maculosa* (Gmel.). Magnolia Warbler.—Rare. More frequently seen a few years ago than now. Breeds.

183 (660). *Dendroica castanea* (Wils.). Bay-breasted Warbler.—Rare. There is a mounted specimen in the Provincial Building.

184 (661). *Dendroica striata* (Forst.). Black-poll Warbler. —Had seen one only up to 1905. Saw a second one on June 16th, 1905.

185 (662). *Dendroica blackburniæ* (Gmel.). Blackburnian Warbler.—Very few of this beautiful species have been seen here.

186 (667). *Dendroica virens* (Gmel.). Black-throated Green Warbler.—Common. Have seen it several years in succession in different localities. Breeds.

187 (671). *Dendroica vigorsii* (Aud.). Pine Warbler.—Have seen it two summers in succession some years ago, not since.

188 (674). *Seiurus aurocapillus* (Linn.). Oven-bird.—Not common. Seen twice, different years, at Mermaid. Breeds.

189 (679). *Geothlypis philadelphia* (Wils.). Mourning Warbler.—Rare.

190 (681). *Geothlypis trichas* (Linn.). Maryland Yellow-throat.—Not common. Found always in low swampy thickets. Breeds.

191 (687). *Setophaga ruticilla* (Linn.). American Redstart.—A common summer resident. Breeds.

Family MOTACILLIDÆ.

192 (697). *Anthus pensilvanicus* (Lath.). American Pipit.—Saw one that was shot out of a flock of five at Pownal, January, 1904.

Family TROGLODYTIDÆ.

193 (722). *Troglodytes hiemalis* Vieill. Winter Wren.—Uncommon. A few are found in the eastern parts of the Island. Breeds.

Family CERTHIIDÆ.

194 (726). *Certhia familiaris americana* (Bonap.). Brown Creeper.—Rarely seen here.

Family PARIDÆ.

195 (727). *Sitta carolinensis* Lath. White-breasted Nuthatch.—Common in some localities. Breeds.

196 (728). *Sitta canadensis* (Linn.). Red-breasted Nuthatch.—Commoner than the white-breasted species and more widely distributed. Breeds.

197 (735). *Parus atricapillus* (Linn.). Black-capped Chickadee.—Common summer and winter. Breeds.

198 (740). *Parus hudsonicus* Forst. Hudsonian Chickadee.—Not as common as the Black-capped Chickadee. Breeds.

FAMILY SYLVIIDÆ.

199 (748). *Regulus satrapa* Licht. Golden-crowned Kinglet.—Uncommon. Breeds.

200 (749). *Regulus calendula* (Linn.). Ruby-crowned Kinglet.—Quite rare. Breeds.

FAMILY TURDIDÆ.

201 (756). *Turdus fuscescens* Steph. Wilson's Thrush; Veery.—An uncommon spring visitor.

202 (759*b*). *Turdus aonalaschkæ pallasii* (Cab.). Hermit Thrush.—Not common. A summer resident. Breeds.

203 (761). *Merula migratoria* (Linn.). American Robin. —A numerous summer resident. An occasional one passes the winter here. Breeds.

SPECIES REPORTED BY OTHER WRITERS.

From Professor Macoun's "Catalogue of Canadian Birds."

In Professor Macoun's "Catalogue of Canadian Birds" there are thirteen additional species, the names of which I have inserted here, with notes of their occurrence as given in that catalogue:

1 (2). *Colymbus holbœlii* (Reinh.). Holbœll's Grebe; Red-necked Grebe.—Large flocks seen on P. E. I., August 8th, 1888 Macoun).

2. (214). *Porzana carolina* (Linn.). Sora; Carolina Rail. —Breeding in P. E. I. (Macoun.)

3 (549. 1*a*). *Ammodramus nelsoni subvirgatus* (Dwight). Acadian Sharp-tailed Finch.—A few birds on the salt marshes at Tignish, P. E. I., were the only ones I could discover (Dwight).

4 (583). *Melospiza lincolni* (Aud.). Lincoln's Sparrow.—A pair was found breeding at Brackley Point, P. E. I., June 26th, 1888 (Macoun).

5 (611). *Progne subis* (Linn.). Purple Martin.—A few pairs breeding at Brackley Point, P. E. I., June, 1888 (Macoun.)

6 (629). *Vireo solitarius* (Wils.). Blue-headed Vireo.—Seen at Hunter River, July, 1888 (Macoun).

7 (654). *Dendroica cærulescens* (Gmel.). Black-throated Blue Warbler.—A few were detected at Souris (Dwight).

8 (672*a*). *Dendroica palmarum hypochrysea* Ridg. Yellow Palm Warbler.—An incubating female taken at Tignish (Dwight).

9 (675). *Seiurus novaboracensis* (Gmel.). Water Thrush.—A few individuals were met with at Tignish (Dwight).

10 (685). *Wilsonia pusilla* (Bonap.). Wilson's Warbler.—One specimen was secured at Tignish in an arbor-vitæ and alder swamp (Dwight).

11 (686). *Wilsonia canadensis* (Linn.). Canadian Warbler.—Rather common about Tignish, but not met with elsewhere (Dwight).

12 (704). *Galeoscoptes carolinensis* (Linn.). Catbird.—A few specimens were seen at Stewart's Mill in July, 1888 (Macoun).

13 (758*a*). *Turdus ustulatus swainsonii* (Cab.). Olive-backed Thrush.—Taken at Covehead Road, July 5th, 1888 (Macoun).

From Francis Bain's "Birds of Prince Edward Island."

1 (106). *Oceanodroma leucorhoa* (Vieill.). Leach's Petrel.—Occasionally blown ashore during storms (Bain).

2 (169*a*). *Chen hyperborea nivalis* (Forst.). Greater Snow Goose.—Individuals of the White or Snow Goose appear in the flocks of Wild Geese early in the season (Bain).

3 (261). *Bartramia longicauda* (Bechst.). Bartramian Sandpiper; Field Plover.—The Bartramian Sandpiper is with us in September and October, and in great numbers falls before the sportsman's deadly piece (Bain).

4 (349). *Aquila chrysaetos* (Linn.). Golden Eagle.—The Golden Eagle visits us sometimes (Bain).

Migration.

This table gives the dates of arrival in the neighborhood of Charlottetown of six birds as given in the reports of phenological observations made by the writer from 1895 to 1905.

I.

	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905
Song Sparrow........	Ap 7	Ap 11	Ap 9	Mar19	Ap 8	Ap 14	Ap 14	Mar31	Mar28	Mar27	Mar31
American Robin.....	Ap 13	Ap 12	Ap 12	Ap 3	Ap 6	Ap 14	Ap 16	Ap 3	Mar26	Mar30	Mar31
Junco...............	Ap 13	Ap 11	Ap 16	Ap 3	Ap 22	Ap 21	Ap 15	Ap 2	Ap 6	Mar30	Ap 6
Swallows...........	May12	May17	May20	My 15	May20	May24	May24	May14	May25	May 5	May13
Night Hawk.........	Jly 22	Jne 28	Jne 11	May27	Jne 4	Jne 5	Jne 1	May23	Jne 13	May28	Jne 11
Canada Goose........	Mar17	Ap 8	Mar27	Mar14	Mar31	Mar20	Mar18	Mar 3	Mar16	Mar 9	Mar22

Table No. 2 gives approximately the times of coming of a few sparrows, warblers and other birds. It does not assume to give exact dates, as no special effort was made to ascertain the times of arrival

II.

	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905
Savanna Sparrow. ...	May19	May 3	.....	.....	May24	May24	May17	......	......	......	. . .
White-throat Sparrow	May19	May 9	May 7	May22	May14	......	......	May18	May12	......	May13
Chipping Sparrow...	......	......	.....	......	......	May24	......	......	May10	May28	Jne 4
Yellow Warbler	May25	.....	......	......	.....	May28	......	......	.....	May28	......
Magnolia Warbler....	......	......	May29	......	Jly 14	Jne 3	Jly 17	......	......	......	......
Blackburnian Warbler	......	......	......	......	Jne 29 May27	......	May19	.....	......	.....	......
Black & White Warbler	......	....	......	......	Jne 17	.....	. ...	.....	Jny 25	.... .	......
Myrtle Warbler	......	......	......	.. ...	......	May17	May 7	May18	May12	May 9	May23
Maryland Y'll'w-throat	......	.....	....	. ...	......	Jne 27	......	Jne 30	.... .	. ....	Jne 4
Redstart	.....	May25	Jne 12	......	May27	......	......	......	Jne 10	Jne 25	May31
Black-throated Green Warbler	......	......	......	......	......	......	May24 Jne 2	......	May25	.....	Jne 26
Brant	Ap 27	Oct 10	Ap 19	......	Ap 29	Ap 17	.... .	......	......	......	Ap 26
Kingbird	May25	....	......	......	......	Jne 3	......	......	......	Jne 1	Jne 4

The following table gives some of the dates when the birds named therein were seen. It indicates the time when they may be expected to be found here :

III.

	1895	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905
Black-cap'd Chickadee	......	......	......	......	May24 Aug 9	......	Jly 31 Nov 7	Ap 2 Dec 28	May10	......	......
American Bittern	......	......	......	......	......	May24	......	......	......	Nov25	Jly 7 Jly 30
Great Blue Heron....	......	......	......	......	......	Aug18	Jly 31	......	......	Ap 7	Jly 7 Jly 10
Semipalmated Plover.	......	......	......	......	......	Aug18	......	......	Sep 3	Sep 1	......
Belted Kingfisher	......	......	......	......	......	......	......	Jne 8	May17	Mar 5	Jly 7 Jly 17
Flicker	......	May 9	May 4	......	May14	May17	May 1	......	May11 Oct 21	......	Ap 20
Phœbe	......	......	......	Mar19	Mar 5 Jne 2	May24	......	......	......	May28	Jne 4 Jly 20
Olive-sided Flycatcher	......	......	......	......	Jne 12 Aug 9	......	......	......	......	......	Jly 20
Purple Finch	......	......	......	......	......	......	......	May 3	May11	Jne 25	May12 May23
Redpoll..............	......	Ap 11	Mar18	......	......	......	......	Ap 13	......	......	......
American Goldfinch..	......	......	Jne 12	......	......	......	May36	Jne 30	May27	......	Aug 1
Cedar Waxwing......	......	......	......	......	......	Jne 21	Oct 22	......	Oct 21	......	Aug10

THE GRIGNARD SYNTHESIS: THE ACTION OF PHENYL MAGNESIUM BROMIDE ON CAMPHOR.*—BY H. JERMAIN M. CREIGHTON, Dalhousie University, Halifax, N. S.

(Read April 9th, 1906.)

As is well known, the organo-metallic compounds have long been used in a great many organic syntheses, as for instance, in the synthesis of the hydrocarbons and the ketones, to take two examples at random. In all these reactions the yields have always been small, and most of the methods complicated, roundabout and unsatisfactory.

By means of the so-called "Grignard reaction" these difficulties have been done away with, the syntheses of a great many compounds effected, and many new compounds prepared.

Compounds of the hydrocarbons with magnesium have long been known, but it was not until recently (1900) that Grignard investigated their action toward different organic compounds.

Grignard found that when methyl iodide was allowed to react with many organic compounds in the presence of magnesium, a vigorous reaction took place and a new compound was formed. When the air was not excluded the mixture took fire. He saw from the variety of ways in which the reaction could be employed that magnesium was likely to make the compounds of zinc and sodium with organic radicles of secondary importance in organic syntheses. Moreover, the reaction should be expected to be more complete with magnesium than with zinc, because magnesium is much more electro positive.

It has been found when an organo-magnesium halide is allowed to act on an aldehyde, or ketone, and the reaction pro-

* Contributions from the Science Laboratories of Dalhousie University (Chemistry).

duct decomposed with water, that secondary and tertiary alcohols are formed respectively, the reactions taking place in accordance with these equations:—

I.

$$\mathrm{R'MgX + RCHO = RCH}\left\langle\begin{matrix}\mathrm{OMgX}\\ \mathrm{R'}\end{matrix}\right.$$

$$\mathrm{RCH}\left\langle\begin{matrix}\mathrm{OMgX}\\ \mathrm{R'}\end{matrix}\right. + \mathrm{H_2O} = \mathrm{RC}\left\langle\begin{matrix}\mathrm{OH}\\ \mathrm{R'}\end{matrix}\right. + \mathrm{Mg(OH)_2 + HX}$$

II.

$$\mathrm{R'MgX + R{-}CO{-}R'' = RC}\left\langle\begin{matrix}\mathrm{OMgX}\\ \mathrm{R''}\\ \mathrm{R'}\end{matrix}\right.$$

$$\mathrm{RC}\left\langle\begin{matrix}\mathrm{OMgX}\\ \mathrm{R''}\\ \mathrm{R'}\end{matrix}\right. + \mathrm{H_2O} = \left.\begin{matrix}\mathrm{R}\\ \mathrm{R'}\end{matrix}\right\rangle\mathrm{C}\left\langle\begin{matrix}\mathrm{OH}\\ \mathrm{R''}\end{matrix}\right. + \mathrm{Mg(OH)_2 + HX}$$

In these reactions the double linking of the oxygen of the aldehyde or ketone is broken, and one of the free bonds of the oxygen unites with hydrogen to form hydroxyl, while the free carbon bond takes up a hydrocarbon residue.

Japan camphor $C_{10}H_{16}O$ contains the ketone group $C{=}O$; under the influence of an organo-magnesium compound, it should therefore form a tertiary alcohol. Zelinsky,[1] who has done a great deal of work on the preparation of cyclic alcohols, found that when camphor is treated with magnesium methyl iodide, and the reaction product decomposed with water, there is obtained a tertiary alcohol whose composition is expressed by the formula $C_{11}H_{20}O$.[2]

No work having been done on the action of organo-magnesium halides of the aromatic series on ketones, it was decided to investigate the action of magnesiumphenylbromide on Japan camphor.

Experimental.

32 g. of phenyl bromide dissolved in 1½ times its weight of ether, was allowed to drop slowly on the calculated amount,

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[1] Ber. d deut. chem. Ges, 1901, 34, 2877.

[2] Ibid.

4.8 g., of cleaned magnesium ribbon contained in a round bottomed flask, to which was fitted a reflux condenser. It is most essential that the magnesium ribbon be perfectly free from oxide. When about $\frac{1}{3}$ of the halide had been added, the flask became warm and a vigorous reaction set in, making it necessary to cool the flask with running water, lest too great heat should cause decomposition.

The calculated amount (17 g.) of camphor, the camphor and halide reacting molecule for molecule, was dissolved in $1\frac{1}{2}$ times its weight of ether and allowed to drop slowly into the magnesium halide. This compound was contained in a round-bottomed flask fitted with a return condenser. The mixture was kept at 60°C. The contents of the flask were allowed to stand over night, the reaction being a gradual one. Next morning the mixture was poured on crushed ice, containing a small excess of dilute hydrochloric acid to dissolve the precipitated $Mg(OH)_2$, and the new product separated out as an oily yellow liquid. These equations illustrate the reactions taking place:—

$$C_6H_5MgBr + C_9H_{16}C=O = C_9H_{16}C\begin{cases} OMgBr \\ C_6H_5 \end{cases}$$

$$C_9H_{16}C\begin{cases} OMgBr \\ C_6H_5 \end{cases} + 2H_2O = C_9H_{16}C\begin{cases} OH \\ C_6H_5 \end{cases} + Mg(OH_2) + HBr$$

The oil was separated from the rest of the mixture and shaken up five times with sodium acid sulphite to remove any ketone that had not been acted upon. It was then washed with water to remove the sodium acid sulphite and dehydrated over calcium chloride.

The oil was then heated in a distilling flask, and at 205-210°C. a vapour was given off, which on cooling, solidified in the condenser to a white mass. This proved to be camphor. The flask was allowed to cool and the contents heated in vacuo, a pale yellow oil distilling over at 150°C.

The yield was nearly ten grams, about twenty-five per cent. of the theoretical yield. As has been mentioned above, the action between the ketone and halide is a gradual one; the small yield and the large quantity of uncombined camphor are probably due to the mixture not having been allowed to stand sufficiently long.

This new alcohol is a pale yellow oil, with a balsam-like taste. It is miscible with alcohol, ether and chloroform. Its specific gravity is 0.977.

The boiling point of this oil is 143°-145°C. at 14 mm. pressure and 258°-260° at 760mm.

Molecular Weight.

Its molecular weight was determined by the Victor Meyer method.

I. The vapour 0.0600g of substance displaced 6.6 cc. air at 715mm. and 19°C giving Mol. Wt. 231.9

II. " " 0.0620 " " displaced 6.8 cc. air at 715mm. and 19°C giving Mol. Wt. 232.6

Mean Molecular Weight, 232.1

Calculated for $C_{16}H_{22}O$, 230.17

Analysis.

Two analyses of the oil were made, but owing to an accident one was a failure, and there was not enough oil to make a third.

0 2510 g of substance :	0 7722 CO_2	0.2 83 H_2O
giving	83.89% C	9.28% H
calculated for $C_{16}H_{22}O$	83.42% C	9.63% H

Specific Rotation.

The specific rotation was determined, but owing to the thickness and colour of the liquid only a small quantity could be used. Consequently the deflection of the plane of polarisation was very small, less than one degree, and the percentage error probably as great as 5%.

The specific rotation $(a)_D$ in alcohol solution was found to be 7°.55′.

The foregoing results show that the compound obtained by the action of magnesiumphenylbromide on Japan camphor is a tertiary alcohol, whose composition is expressed by the formula,

$$C_{10}H_{16}\begin{matrix} OH \\ C_6H_5 \end{matrix}$$

This is analogous to the tertiary alcohol,

$$\text{methyl borneol, } C_{10}H_{16}\!<\!\begin{matrix} OH \\ CH_3 \end{matrix}$$

prepared by Zelinsky, and should therefore be called phenyl borneol.

Dalhousie University, Halifax,
April 1st, 1906.

THE OIL-FIELDS OF EASTERN CANADA.— BY R. W. ELLS, LL.D., F. R. S. C., Geological Survey cf Canada, Ottawa.

(Read 12th March, 1906.)

The occurrence of petroleum or rock-oil has been known from a very early date in the world's history. It is referred to frequently in Holy Writ under such names as slime or pitch, in connection with the building of the city of Babylon, the construction of the ark, the preparation of the cradle of Moses, etc. It was found in considerable quantity in the valley of the Dead sea, whence it was transported to Egypt and to the ports on the Mediterranean, where it was extensively employed in ship-building, as well as by the Egyptians and other nations in the embalming of the dead. Many references to this substance are also found in the works of profane writers, more especially of Herodotus, Plutarch, and Josephus; while the ancient sect of Guebers or Fire-worshippers of Persia apparently derived the visible symbol of their religion from the oil-springs and accompanying natural gas of the Baku district, now in southern Russia, but till within the last 200 years a part of the Persian empire; or from similar occurrences in other parts of Persia and in India, in both of which countries the presence of this substance has been known for many centuries. In some places also, as in China and Japan, natural gas, which is frequently an accompaniment of petroleum, has been used for a long period for both heating and lighting purposes.

In certain parts of Europe where petroleum occurs in the form of springs it has long been used medicinally, and has been regarded as a valuable remedy for rheumatism and other kindred diseases. So also in the early history of Canada and the northern States, crude petroleum, under such names as Seneca and British oil, was extensively employed for various

ailments and commanded quite a large price, the material being obtained from the natural springs which are found in western Ontario and southern New York or Pennsylvania adjacent to the south.

Petroleum or rock-oil is in fact a substance of almost world-wide occurrence. It has been found in nearly every country in Europe and Asia; in some of the islands of the Pacific and Indian oceans; in New Zealand and Australia, and in North and South America. It is especially abundant in the United States and in Canada, occurring in many places from the Atlantic to the Pacific. It has been asserted by some authority that in its distribution it is only surpassed by water itself, but whether this statement can be maintained or not, it may safely be said that petroleum in some form is one of the most widely known of mineral substances to-day.

Its wide range in distribution over the earth's surface is only equalled by its extended geological occurrence, since in some one of its many forms it has been found in most of the formations or systems from the earliest Laurentian to the latest Tertiary. The result of the study of this material within the last thirty years has been to do away very largely with the old theory that rock-oil was practically confined to rocks of Devonian and Upper Silurian horizons. In face, some of the largest known deposits at the present day are found in the newest rock-formations, while other very large oil-fields have their location in rocks of Trenton age. In so far as the geological horizons are concerned therefore, it would seem in the present state of our knowledge, to be a difficult matter to predicate just where petroleum or some one of its related substances may or may not be found. A safer test as regards deposits capable of economic development would appear to be connected with the geological conditions which prevail in the special field to be exploited.

Petroleum, in the form of crude oil, is doubtless one of the most important of the bituminous compounds. Several other var-

ieties are, however, found, among which may be mentioned anthraxolite, asphalt, ozokerite, albertite, manjak, etc. Petroleum can also be obtained in large quantities from certain rock formations which abound in bitumen, such as the Utica shales of Ontario and Quebec, the Albert shale of New Brunswick, the stellarite of the coal areas in Pictou, and various other formations found in widely diverse portions of the globe. In a number of cases these formations have been extensively utilized as a source of supply for petroleum, as in the case of the bituminous shales of Scotland, France and elsewhere, while in Canada in the early years of the industry, quite extensive plants were erected in Ontario for the distillation of the Utica shale, and in New Brunswick of the Albert shale deposits. Unfortunately for these industries the discovery of the great reservoirs of crude petroleum in the United States and in western Canada (Ontario) speedily reduced the price of the raw material so that its further extraction from the shales became unprofitable, and this industry was long since abandoned.

The mineral anthraxolite, appears to be to all intents merely a hardened or thickened petroleum, and has been found in rocks as low down as the Laurentian and Huronian, where it occurs in vein form in granitic or associated rocks in Ontario; in slates of lower Cambrian or Huronian age west of Sudbury, at Chelmsford; and in the Black river limestone associated with baryte near Kingston. In Quebec it has been found in veins traversing slate and quartzite of lower Cambrian age in Labrador; and in irregular deposits in slates of the Sillery and Lévis formations near the city of Quebec. It is very probable that future examinations may reveal its presence elsewhere in these old rocks. In some places, as near Chelmsford, the quantity is considerable, and, if sufficiently pure, might be worked, but the large percentage of ash in its composition interferes with its utilization as a suitable fuel for domestic or steam purposes. At one time great hopes were

entertained by certain persons that Ontario had at last obtained a fuel supply peculiarly its own, and it is to be regretted that these expectations have not yet been realized. So also at Quebec it was at one time anticipated that workable deposits might be obtained, the mineral found at this place giving fairly satisfactory results as a fuel. It was, however, found, on attempting development, to be confined to mere strings and pockets of no commercial importance.

The presence of these carbon compounds in rocks of great antiquity would, on the hypothesis that all these substances, including graphite, are of organic origin, carry the life history of the globe to a very remote period. While it is no doubt true that organic remains are found as far back in time as the early Cambrian period, and in some of these older rocks are abundantly displayed, crude petroleum in workable quantity has not yet been found therein. Moreover, the presence of petroleum and its kindred minerals in rocks of igneous origin, such as basalts and various diorites, where there is no indication of sedimentary rocks or traces of organic life opens up another aspect of the question that should receive careful consideration. In this connection it may be stated that petroleum in some of its forms occurs in greenstone and basalt, hornblende rocks, augite, feldspar, etc., at various places both in Europe and America. It is found in the Laurentian, both in Scotland and Canada; in melaphyre at several places; in the granite of Cornwall, England; and in trap rocks both in the province of Quebec at Gaspé, in connection with Devonian slates, and on the west coast of the Queen Charlotte islands in basalts of Tertiary age.

In so far as the petroleum deposits of economic importance occur on this continent it may be said, generally speaking, that in the eastern or Atlantic division these are confined to Silurian, Devonian and Carboniferous rocks, while in the western or Pacific division they belong to formations of Cretaceous and Tertiary age.

The various geological formations in which crude petroleum is found in various parts of the world may be briefly stated. Thus in the Baku district of southern Russia, where probably the largest and most productive wells are situated, the associated rocks are somewhat incoherent sandstones of recent Tertiary age, so incoherent, in fact, that the oil which outflows in immense quantities contains a large percentage of sand which has to be separated after collecting the oil. In India, Burmah, Assam, Beloochistan, Persia, Japan and China, oil is found in workable quantity in rocks of the same general horizon or from some portion of the Tertiary formations, wherever the conditions are favourable to its occurrence. Of these an interesting feature is seen in the oil wells of Beloochistan, where, owing to the disturbed and faulted character of the strata, attempts to obtain the minerals in paying quantities have proved a failure.

In the group of islands comprising Borneo, Java, Sumatra and Timor, as well as in the Phillipines, the oil-bearing rocks are also of Tertiary age, and this is likewise the case with the deposits of New Zealand and of Australia.

In the South American states it occurs in rocks of practically the same horizon, as well as in Mexico and in the islands of Barbados and Trinidad; while along the west coast of United States, from Texas on the south to Alaska on the north, as also in territory bordering the east side of Rocky mountains, in oil-fields of Colorado and in Alberta, the containing formations range from the Cretaceous into the Tertiary. In Canada on the Pacific coast no oil-wells have yet been reported, but traces of oil have recently been found in connection with the Tertiary sandstone and shale of one of the interior coal basins. On the east slope of the mountains, however, borings have been carried on for several years in connection with oil springs which are supposed to issue from Cretaceous rocks, while the great deposits of tar sands which occur along the Athabasca and

upper Peace rivers, in the district north of Edmonton, also belong to the same horizon. The recent flows of natural gas which have been struck at Calgary and at Medicine Hat in the country of the plains, are also from strata of Cretaceous age.

In Europe it is also of interest to note that the oil-wells, in so far as these are at present productive, belong to recent rather than to Palæozic times. Thus in Italy petroleum is found in Tertiary sediments along anticlines which follow generally the trend of the Appennines; in Germany in the Tertiary in part and partly in the underlying Jurassic; while in Great Britain, France, Spain, and Switzerland, in Europe, and in Algeria and Egypt in Africa; it occurs also in rocks pertaining to the Cretaceous and Tertiary formations.

It will be seen, therefore, that in the greatest number of petroleum producing countries the mineral is obtained from formations which are quite recent as regards the geological scale. Coming nearer home, however, we find, as a rule, that petroleum pertains rather to rocks of Palæozoic age. In Canada these have usually been assigned to the Devonian system, since it was long supposed that it was from these formations that the wells derive their flow of oil; but in the United States some of the most productive wells are sunk in formations as far down as the Trenton. On this continent, therefore, there appears to be a marked line of separation as regards the horizon of both coal and petroleum, between the occurrences east of a line defined by the Mississippi river for the United States side of the boundary, and by the eastern edge of the prairie country in Canada which divides the deposits of Palæozoic age on the east from those of Cretaceous and Tertiary age on the west.

In character also petroleum varies greatly in different districts. It ranges from a highly fluid condition and a light colour in some areas, to a thick and exceedingly dark coloured substance in others; the specific gravity of the mineral, according to observations made by Boverton Redwood, having a

proportionally wide range, extending from 0.771 to 1.020. As a rule, the lighter oils yield a larger percentage of kerosene than the heavier grades. Comparing the oils of western Ontario with those from the celebrated wells found in the United States it is found that the Canadian product has a somewhat greater specific gravity, while tests made on the oils taken from the wells in Gaspé during the borings some years ago, gave sometimes a still higher specific gravity. The oils of western Ontario have also a more offensive odor than many of those to the south, due presumably to the presence of sulphur.

In colour, native oils range from a light yellow to a black or brownish-black, and often with shades of green. In regard to density this is measured by what is known as the Baumé scale, in which the lower the grade on Baumé the higher the specific gravity of the oil; thus, 10 degrees Baumé is equivalent to specific gravity 1.000, while 90 Baumé is the equivalent of an oil with specific gravity 0.6363.

Turning now to the consideration of the conditions under which petroleum in economic quantity is usually obtained, it will be observed that the general arrangement of the rock formation is a very important factor, whether the locality be underlaid by rocks of the older or the newer horizons; and this feature is sometimes lost sight of in search for new oil-fields. For not only must the rocks in which the oil is supposed to occur lie in a nearly horizontal attitude, or in the form of low swelling anticlines but the oil itself must be kept in by an impervious covering of shale or some other rock. If in the case of a rock series, which is supposed to carry oil in greater or less amount, this covering is broken or faulted or the rocks, as a whole, are more or less tilted and disturbed, it is probable that the cementing cover is quite unequal to holding down the underlying oil, which will therefore in some way tend to find an outlet to the surface, and will have been lost in ages long since past. It is, therefore, evidently unwise, to say the least,

to waste much time or capital in an attempt to obtain oil in quantity from an area where the rock formations are much disturbed. In several such cases small quantities of petroleum have indeed been obtained, sufficient for the time to lead the explorer to invest additional sums of money, though the final outcome, as might have been expected, has generally been disastrous.

On the hypothesis now generally accepted, oils have originated from the decomposition of animal or vegetable organisms which have been buried during the process of rock formation precisely as we see going along our sea shore at the present day, where shells, seaweeds, fish, etc., are buried by the accession of sands or other materials which are moved by tidal currents or by wind action.

These decomposed organisms, with their resulting carbon contents, were supposed by Dr. T. S. Hunt to be the actual source from which petroleum was derived, and the resulting oil to form a part of the formation in which they are deposited, preferably in limestone, since their remains were easily recognized and were often observed to be highly charged with oily matter in the several strata encountered. He, therefore, contended that petroleum originated from the primary decomposition of organic matter and pertained to the stratum in which the organisms were first laid down. Another school, however, contended that the original source of the petroleum was in some lower stratum, and that the oil resulting from the decomposition of organic matter, as well as the accompanying gases, rose or percolated through underlying sediments till they encountered a non-pervious layer, being assisted in this upward movement by the action of percolating waters at a greater underlying depth.

On this latter theory the oils of the Petrolia district, which may be taken as an example of the general principle, have originated at some lower horizon than that in which they are

now found by boring, and have ascended gradually till they have met the porous dolomite of Devonian age in which they now seem to occur. They were held in place by the overlying cover of grey shales which succeeds the limestone, and which by the drillers is usually called "soapstone", and by this impervious cover, under great pressure, are hermetically sealed till the overlying rock is pierced, when they make their escape to the surface with tremendous force. The strata throughout the Ontario oil district lie in an almost horizontal position or in gentle anticlines so low that the dip of the beds is scarcely perceptible to ordinary measurements.

To go into elaborate details as to causes and effects would, however, swell the present paper to too great lengths. They can be well studied by reference to the excellent report by Dr. Orton on the "Occurrence of Petroleum, etc., in Kentucky," and in other bulletins of a special nature relating to the subject.

While rock-oil and natural gas are widely distributed throughout the Dominion of Canada, and while attempts to work many of these deposits have been made at a number of places from time to time, it is to be regretted that in many cases such efforts have been usually attended with a lack of fruitful results. Much of this unnecessary expenditure could have been avoided had due attention been given to the geological features of the several areas which have been tested.

In so far as boring investigations for oil are concerned in Canada it must be confessed that up to the present the original field in south-west Ontario has been the only one that has given satisfactory results. It is, however, confidently expected that at some future time portions of the great Cretaceous plain east of the Rocky mountains, in which large supplies of natural gas are now being developed, will be found to be also oil-producing; but this is still matter for future investigation. It may, however, be stated that the Pierre shales, in which the oils of the Florence basin in Colorado occur, have an extensive development in the Canadian north-west.

In the Atlantic provinces of Canada explorations for petroleum have been carried on at intervals for many years, in Nova Scotia, New Brunswick and Quebec as well as in Newfoundland. So far only negative results have been obtained, but a study of the several fields in which operations have been conducted will present some features of general interest.

In contrast with the oil-fields of western Ontario or of the eastern States, in both which areas the oil-bearing rocks lie in nearly horizontal layers, either of sandstone, limestone or shale, the rocks of the eastern areas in Canada are more or less disturbed, being thrown into folds with their accompanying faults and dislocations.

Although the island of Newfoundland is not politically a part of Canada, geologically speaking its oil-fields are related and may be considered in this place. Of these there are at present but two in which operations have been carried on, viz., at Port au Port bay, north of St. George's bay, and on the west coast further north, at Parson's pond.

In the article on petroleum published in the Annual Bulletin of the United States Geological Survey, these occurences are assigned to Cambrian rocks. The reason for this is not very clear, for during a visit to the former locality, several years ago, a brief study was made of the district by the writer which led to very different conclusions.

The two principal geological formations found around the shores of Port au Port bay from the Gravels east and west, are 1st., a series of fossiliferous limestones of the Lévis or Calciferous formation, a part of the old Quebec group of Canada, and 2nd., an unconformably overlying series of fossiliferous shales and limestones of Lower Carboniferous and Upper Devonian age, portions of which are faulted down into the Calciferous division which forms prominent ridges along the shores of the bay. Towards the inner end of the long point, on which the borings are situat-

ed, these Carboniferous rocks occupy the shore for some distance and extend for several miles out to the end of the point itself, though concealed in part by peat deposits, in which distance they also appear to include portions of an underlying series of Devonian shales. On the eastern side of the bay, where borings have also been made, the sales and sandstone are again exposed, and include bands of bituminous shale, which exactly resemble certain bands in the Albert shale series of New Brunswick. The shales on both sides of the bay are much disturbed, with numerous faults and dislocations, and in places contain remains of plants. It is in this series of rocks that the oil-wells of Long point have been sunk, as well as those on the east shore already referred to.

While indications of petroleum are seen at several places along the beach in the form of oozings or small springs, and while it was found in small quantity in several of the bore-holes, the amount thus obtained was in all cases unimportant from the economic standpoint, and the geological conditions were such as to warrant the conclusion that the expenditure of further capital in the locality was not advisable. Similar conditions apparently exist at Parson's pond to the north, where the oil-bearing rocks are apparently of the same horizon, judging from the statements published on the work done in that district, and are affected by a like series of folds and breaks as at Port au Port. The results of the borings at this place are apparently quite similar to those already described, the oil occurring in small quantity, while the geological conditions appear to be equally unfavourable as at Long point. The geological horizon of these deposits, therefore, instead of belonging to the Cambrian is assignable to the Devonian or lowest part of the Carboniferous, probably the former.

Crossing the Gulf of St. Lawrence to the Gaspé peninsula, in the province of Quebec, we reach another oil-field which has been known for half a century, and in the exploitation of which

very large sums of money have been spent in a vain attempt to find petroleum in paying quantity. More than fifty years ago Sir William Logan recognized the existence of oil-springs in this district, and they were described in his earliest reports as situated in places sometimes near the shore and sometimes inland. Attempts were made as far back as 1866 by a boring located near one of these springs to find the source from which the outflow was derived, and the boring reached the depth of nearly 700 feet. Here a small quantity of oil was reported, but owing to the loss of the boring tools the hole was abandoned, the occurrence of oil being apparently insufficient to warrant further expenditure at that time. Subsequently the Petroleum Oil Trust began an extensive series of borings in 1889, which were carried on for nearly fifteen years, and in connection with the Canada Petroleum company, an area extending inland for some thirty miles and with a breadth of six to ten miles, was very thoroughly explored by boring, several of the holes being sunk in close proximity to the original location near the spring already referred to. In all, more than fifty holes were bored, some of which reached a depth of over 3700 feet. The results of all these borings have been collected and were given to the public in a report by the writer to the Geological Survey Department in 1902. An interesting fact was disclosed in the several borings made at the original site, in that, though a depth of over 2400 feet was reached no oil was found beyond mere traces; the rocks are highly inclined at this place, and there is probably a line of fault and an anticline in the vicinity.

The rocks of this district belong to the Devonian system, of which a section aggregating 7000 feet is exposed along the eastern Gaspé shore. Generally speaking, these rocks are inclined at high angles, in some places reaching sixty to eighty degrees. Faults are seen at several places, and intrusive dykes of diabase also occur, one of which of large size at Tar point is remarkable for containing petroleum, sometimes as a solid, but

generally in liquid form, disseminated through the igneous rock in drusy cavities, some of which are lined with chalcedony.

The area is also traversed by well defined anticlines, running generally in an east and west direction; and in several places these are affected by fault lines. It is near these lines of fault that most of the oil-springs are situated.

As might be anticipated from a close study of these rocks conditions favourable to the occurrence of oil in quantity are absent, owing, in large part, to their usually highly inclined character and to their broken condition. In fact, the area if it ever contained petroleum in quantity, of which, however, there is no particular indication, would have been deprived of its stores long since by escape along these lines of fracture. Be that as it may, it has been clearly demonstrated by the expenditure of large sums of money and by the sinking of numerous wells to great depths, that with but few exceptions, the rocks passed through are now practically barren as regards oil. In some of the wells it would appear that there is a small amount of oil which finds its way into the bore-holes, probably by seepage from the surrounding strata, which can be obtained by pumping, but in most of the holes bored there was evidently no trace of oil whatever, though from a number water is still flowing freely.

The results obtained in this area, as in Newfoundland, tend to strengthen the theory, already well proved in the western oil-fields, that productive wells in eastern Canada must be sought for in rocks which are comparatively undisturbed, and preferably with low anticlinal dips, and while the records of the wells bored in the Gaspé district show in several cases the occurrence of oil, aggregating an output of some hundred of barrels, the general principle laid down is still maintained.

In the province of Quebec no other occurrences of petroleum are as yet recorded, the bituminous matter found at Lévis in the form of anthraxolite, and in Labrador being excepted.

In the flat country lying east of Lake St. Peter, which is an expansion of the St. Lawrence between Montreal and Quebec, boring operations have been carried on for more than twenty years, some of the holes being sunk to depths of more than 1000 feet. The rocks of the district in which the borings have been made belong to the Lorraine and Medina formations, which lie in a comparatively flat basin extending across the St. Lawrence westward. Though natural gas in considerable quantity has been found, this has not yet assumed large commercial importance, but no petroleum has yet been met with.

In Nova Scotia, rocks supposed to be oil-bearing occur at several places. Probably the most important area of these is found in Cape Breton on the shores of Lake Ainslie, where attempts have been made for a number of years to find petroleum in quantity by boring. Here, as in Gaspé, the indications of rock-oil are observed in the form of springs and oozings, which escape from shales along the lake shore.

The rocks consist of shales and sandstone, generally of grey or greenish shades, which contain plant stems and fucoids. They have been classed provisionally as Lower Carboniferous, but as they clearly underlie the lowest known rocks of this formation it would seem more fitting to include them, on stratigraphical evidence, as a part of the Devonian series. They correspond closely in character and position with those rocks which are regarded as of the Devonian age elsewhere in this province and in New Brunswick.

Attempts to obtain oil by boring were commenced on the east side of this lake half a century ago; but though many holes have been put down, some of which reached a depth of 3000 feet, these have as yet been unsuccessful in finding oil in quantity. As in Gaspé and elsewhere, the strata are usually much broken up and inclined at high angles, with a well marked faulted structure in places. This feature is pointed out by Dr. I. C. White, of Virginia, in his report on the probable oc-

currence of oil in this distrct, where he says "the area of the field is so limited and the dip of the strata so high that there is hardly a chance of its being obtained here in large enough quantity to pay for its development." The area has apparently been fairly well proved in depth, and it would appear that any petroleum that may at one time have been present in these rocks has long since passed off along the lines of fracture.

On the south side of Minas basin, at Cheverie, and on the Avon river, near Hantsport, borings for oil have been carried on during the last three years. Along the Avon, below Hantsport, a considerable thickness of shale and sandstone, with occasional beds of limestone, outcrops. These are regarded as the equivalent in age of the celebrated Albert shales of New Brunswick, though the percentage of bituminous matter is much less in the Avon, or, as they are usually styled, the "Horton series". Though for many years regarded as a portion of the Lower Carboniferous formations they are now considered as belonging to the Devonian system; since they uncomformably underlie the lowest known Lower Carboniferous rocks in this province.

These shales extend eastward from the Avon to the south side of Cobequid bay, and at Cheverie underlie a considerable thickness of gypsiferous rocks also associated with sandstone and shales. In the borings which have been made at this place the drill passed through these gypsiferous strata and entered a series of shales, etc., which were supposed to be a part of the oil-bearing series. In the underlying rocks indications of petroleum are found in cavities and crevices in the gypsum itself, and the borings were put down on the assumption that when the underlying bituminous shales were struck the source of these oils would be found. These underlying rocks are, however, much disturbed, and no trace of petroleum was encountered when these were reached.

This tilted and faulted character is well seen in the section of these rocks exposed along the lower Avon, and the boring

made near Hantsport in this formation was also devoid of results as regarded the finding of either coal or petroleum. As is Gaspé and elsewhere it may be generally inferred that in such a series of titled and faulted strata the chances of finding oil in economic quantity are by no means good, and the ultimate result of all these attempts, at places so widely separated, will probably be the same.

The only other source of petroleum known to us in this province is the band of "Stellarite", found in association with one of the coal seams of the Pictou basin. This mineral is reported to yield more than 100 gallons of crude oil per ton by distillation, equalling in this respect the Albertite of New Brunswick and the Torbanite of Scotland, both of which are now practically exhausted. No attempt has been made in recent years to utilize this mineral for the manufacture of oil.

It would appear that as a rule the shales of the eastern provinces do not, readily yield oil except by distillation although in places containing a large percentage of bituminous matter in composition; and from the results which have attended the borings at a number of points no large deep-seated reservoirs of liquid petroleum are likely to be encountered from which "gushers" may be derived.

The largest and most important body of these bituminous shales occurs in Albert county, New Brunswick, whence the name "Albert shale". Attention was directed to this locality more than half a century ago by the finding of a body of what was at first supposed to be a coal of superior quality. Some persons, however, contended that the substance had more of the nature of hardened pitch or asphalt and was not a true coal, and a legal contest ensued since the ownership of the property depended upon the actual determination of this question. Finally, after hearing a great mass of so-called expert evidence, the finding of the court was to the effect that the mineral in question was a true coal and not an asphalt, only two

of the experts maintaining its asphaltic nature. Subsequent investigation has clearly shewn that this early decision of the court was erroneous, and it has long since been established that Albertite, as the mineral was called, is merely an altered petroleum.

The Albert shales were for many years regarded as a part of the Lower Carboniferous formation, purely on the evidence of certain fossils, chiefly the remains of fishes. The detailed investigations of 1876, however, shewed them to unconformably underlie the lowest known Lower Carboniferous sediments, and they are now generally held to form the upper part of the Devonian system.

The peculiar feature of these Devonian shales is the presence of bituminous matter throughout their whole extent. While the great bulk of these sediments are shales, beds of sandstone and limestone also occur as a part of the series, and both are also highly bituminous. Interstratified beds of a tough, blackish and massive shale also occur, which break with a roughly conchoidal fracture and contain a much higher percentage of bitumen than the shales of the general mass, which are often thin-bedded.

The source of all this bituminous matter is somewhat obscure; for while according to strict orthodoxy the contained bitumen is supposed to be derived from organic matter contained in the mass of the rock itself, and while in certain layers the remains of fossil fishes are fairly abundant and occasionally the traces of plant life are visible, the proportion of fossiliferous strata, as compared with the great body of bituminous shales, is very insignificant.

The bands of rich oil-shale are sometimes styled Cannelite. They are occasionally grey in colour but for the most part are a blackish-brown. They are clearly a portion of the series, occurring as regular beds. At the old Albert mines, which were near the eastern end of the Caledonia mountain, a very

large deposit of Albertite occurred, and was worked extensively some years ago. This was the mineral first discovered in this district and which was pronounced to be bituminous coal by the courts. It occurred in vein form, following a line of fissure not far from the axis of an anticline in the shales. This deposit extended from east to west for about half a mile, with a width ranging from a few inches at either extremity to a thickness of from fifteen to seventeen feet near the middle of the outcrop. In depth the fissure continued for 1500 feet, the lower 250 feet being for the most part filled with a breccia made up of shale fragments cemented with Albertite.

The extent and value of this deposit can be understood from the fact that during the time of working over 200,000 tons of the mineral were marketed at prices varying from $16.00, in the early years of the industry, to $22.00 per ton, for some years before the mine ceased operations. It yielded about 15,000 feet of gas per ton and more than 100 gallons of oil by distillation.

The Albert shales with their associated oil-bands cover a considerable area in the counties of Albert and Westmorland. They extend from east to west for more than sixty miles, and have a thickness of not far from 1,000 feet. They are thrown into a series of folds, often with steep dips, and are broken by faults at a number of points. To the west they again outcrop near the line of the Intercolonial railway to the vicinity of Hampton, in Kings county. They are in places overlaid by Lower Carboniferous shale and conglomerate, with which are associated large deposits of gypsum and thick beds of limestone in parts also bituminous, and in other places are capped directly by the coarse beds of the Millstone grit.

All the shales of the series yield oil by distillation, the bulk of the formation probably from fifteen to thirty gallons per ton of shale, while the rich oil-bands, or cannelite, yield from 50 to 80 gallons. These bands were about forty years ago

worked for the extraction of the contained petroleum at Baltimore, N. B. They range in thickness from four to eighteen feet, the thicker bands being of the grey variety and found near the upper part of Turtle creek in the western portion of the main field. They can be mined after the manner of ordinary coal-beds, and while the amount of ash is large, reaching in parts from 40 to 50 per cent., the shale burns readily, forming an excellent fuel, both for grates and for the generation of steam. As determined by actual experiment it is claimed that their combustion yields a greater heat and calorific power than can be obtained from ordinary bituminous coals, while the large amount of ash is held to possess certain elements which make it valuable as a fertilizer.

Although these shales contain so large a percentage of bituminous matter they do not readily part with this in the form of free petroleum either by shafting or boring. In support of this statement, it may be said that during the entire period of mining operations at the Albert mines where one would naturally suppose conditions were most favourable for the free escape of the contained oils, according to the statement of the late manager, but slight indications of crude petroleum were observed in any part of the workings, except at one point near the west end of the mine, where there was a slight dripping from the end of the mine, where there was a slight dripping from the sides of the drift. On the Petitcodiac river, near Dover, and at several points in the vicinity, several oil-springs occur, and have usually been regarded as indicating the presence of underlying reservoirs of this material. As at Gaspé and elsewhere, however, in such disturbed rocks these are more probably escapes of petroleum along lines of fracture, and can scarcely be held to indicate the occurrence of oil in quantity in the underlying rocks.

Boring operations have been carried on in this district for more than fifty years. Apparently the first holes were sunk in

the area near Dover and Memramcook, between 1850 and 1860, the exact date being somewhat uncertain, as records of these borings are not now available. It was, however, reported at the time, that small quantities of a thick oil were obtained. Subsequent borings were made at intervals for some years with apparently no better results, but within the present century a systematic search has been carried on in the area between Memramcook and Petitcodiac rivers, in which over sixty holes have been bored, some of which reached depths of more than 3000 feet. While small quantities of oil were struck in some of these holes, as was also the case in Gaspé and in Newfoundland, in rocks of practically the same horizon, in so far as can be learned no outflows have as yet been found in quantities sufficient to warrant the erection of an extensive refining plant, and at present operations have been suspended for some months.

The nearest geological formation to which these Albert shales can be compared from the economic standpoint, are the bituminous shales found in Scotland, and to some extent, in England and Wales. They also occur and have been utilized for the production of oil by distillation in some parts of Australia, in New Zealand, in France, in Germany and in several other countries. In none of these places, however, have they been regarded as producers of crude petroleum in any other way than by destructive distillation.

Their economic importance is evident from the fact that in Scotland and elsewhere millions of pounds have been invested in the erection of large plants for the distillation of the contained bituminous matter, and a brief comparison of some of these Scotch shales with those of New Brunswick may possess some points of interest.

In Scotland, since it is not necessary to discuss the shale-oil industry of other countries, the distillation of oil, first from bituminous coal and then from bituminous shale, was begun by Dr. James Young, of Renfrewshire, about the middle of the

last century. The first experiments were made with the bituminous coals, but the discovery of a mineral, very rich in bitumen, which was known as Bog-head coal or Torbane hill mineral or Torbanite, soon furnished a new supply of the raw material. This Torbanite yielded as much as 130 gallons of crude oil to the ton, as compared with a yield of from 70 to 90 gallons from the coal. After the exhaustion of the Torbane hill mineral attention was directed to the bituminous shales of the coal-measures which were first worked in 1862.

The growth of the shale-oil industry in Scotland may be seen from the fact that the output of this material in 1874 was only 361,970 tons, while in 1891 this has risen to 2,337,932 tons for Scotland alone, yielding 47,63,458 gallons of crude shale oil, the amount of capital invested being for that year no less than £2,664,431, the yield of oil being much greater than the output of crude petroleum in the whole of Canada for the year 1904.

The shale series in Scotland is estimated to have a thickness of about 3000 feet, and in this eight principal bands of oil-shale occur, varying in thickness from two to eighteen feet, and are thus not very different in quantity from those found in the Albert shales of New Brunswick.

Of the Scotch shale bands which most nearly resemble those of Albert county, though none appear to contain as high a percentage of bitumen, the richest, known as the Fell shale, yields from 36 to 40 gallons of crude oil to the ton, and from 25 to 33 pounds of ammonium sulphate; the Broxburn band is probably next in importance with a yield of 28 to 33 gallons crude oil, and from 26 to 32 pounds ammonium sulphate; the Dunnet shales yield from 15 to 30 gallons, and the Curley shales yield about 19 gallons of crude oil and from 50 to 60 pounds ammonium sulphate. In geological position these Scotch shales correspond almost exactly with those of New Brunswick, being situated between the Lower Carboniferous limestone and the Old Red sandstone of the Devonian.

These several oil bands are mined after the fashion of bituminous coals, and are delivered at the distillation works at a cost of four to six shillings per ton. There is also a royalty of from three to tenpence per ton of shale, and the cost of the finished illuminating oil, after crediting the value of the ammonium sulphate, is two and a half pence per gallon. Much of this detail is taken from the valuable work of Boverton Redwood, in whose book on "Petroleum and its products" a very full description of the industry in all its stages is given.

Comparing then the small size of the Scotch seams and the comparatively low percentage of the bituminous contents with the generally thicker beds of Albert county and the much higher percentage of bitumen, the economic importance of these deposits, as a possible source of supply for crude petroleum becomes at once apparent; and in the present strenuous search for new oil-fields and the rising price of the finished product, it would seem perfectly feasible under proper management to operate these New Brunswick areas with a fair margin of profit; more especially in view of the now well established fact that these shales, whenever they are found, do not readily yield up their bitumen contents except by distillation. The further consideration of this question is, however, a matter for the careful consideration of the best expert engineering skill, and careful management is required in all its stages.

Considered from the standpoint of fuel under steam generating boilers, it has already been hinted that some of these heavy bands of oil-shale possibly could be utilized as a source of heat and power. Of these there are two kinds, the black being especially well developed at the old Albert mines and at Baltimore in Albert county, as well as in parts of the district between the Petitcodiac and Memramcook rivers, having been shipped quite extensively from the latter area for distillation in 1860-65. The grey shales are better developed in the area west of Baltimore on the head waters of Turtle Creek;

the analysis of these shales is of interest and may be here given. They are from the laboratory of Ricketts and Banks, of New York, and are as follows:—

Black oil-shale.

Moisture	0.36	0.64
Volatile	39.50	45.52
Fixed carbon	3.00	5.05
Ash	56.10	48.79
Sulphur	1.04	.....
	100.00	100.00

Grey oil-shale.

Moisture	1.10	1.54
Volatile	45.32	51.22
Fixed carbon	1.29	3.03
Ash	50.69	44.21
Sulphur	1.70	.....
	100.00	100.00

As already stated the origin of the immense amount of bituminous matter contained in this body of shale and sandstone has never been satisfactorily explained, and is a very interesting problem. On no hypothesis yet suggested can it be accounted for either as arising from the decomposition of organic matter *in situ* or as derived from underlying fossiliferous sediments, since the underlying rocks being of pre-Cambrian age are entirely devoid of all trace of organisms. Similar difficulties are also met in the attempt to explain the origin of the great deposits of bitumen found in the island of Trinidad, where the associated rocks are shales of Tertiary age. While the consideration of the several theories put forward from time to time to account for the bituminous deposits throughout the world would be of considerable interest, and while the inorganic origin of bitumen and its compounds has quite a number of supporters at the present day, such discus-

sion is beyond the scope of this paper, and if indulged in would probably leave the final determination of the problem in its present unsatisfactory position.

We may, however, glance for a moment at the enormous output of crude Petroleum which has been obtained from certain parts of the well known oil-fields of the eastern and western hemispheres. Without considering the amounts derived from the smaller areas it will suffice to note that from the official returns of the Geological Survey of the United States, the number of barrels of crude petroleum of 42 gallons capacity, taken from the oil-fields of that country since the commencement of the industry forty-five years ago, amounts to 1,382,815,000, or nearly sixty billions of gallons, by far the greater part of which has been obtained from what is known as the Appalachian district, comprising the states of New York, Pennsylvania, West Virginia, south-east Ohio and Kentucky, only comparatively small portions of which are oil-bearing. These oils are all obtained from the Palæozoic formations. The recent discovery of the immense stores of petroleum in Texas, California and from other areas on the Pacific slope is to some extent already revolutionizing the industries of that portion of the republic by the substitution of oil for fuel on railways and steamships. These oils are from the much more recent horizon of the Cretaceous and Tertiary formations, and some of the areas are already rivalling in productiveness the original seat of the industry in the Appalachian district. The value of the oils for the time mentioned for the entire output to the end of 1904 is given as $1,362,781,879.

The value of the petroleum produced in Canada from the commencement of the industry cannot be correctly stated owing to the fact that for some years the returns were loosely kept. For the period extending from 1881 to 1903, both inclusive, the production of crude petroleum in this country was not far from 530,000,000 gallons, the output being practically all from the

small area in south-western Ontario. The actual value of the output cannot be stated.

In southern Russia a most wonderful revelation as to the amount of crude petroleum which can be obtained from a limited area is presented. Thus from the oil-fields of the Baku district at the southern end of the Caspian sea, in an area of about eight square miles only, and in a period extending only from 1880 to 1904, the output of petroleum amounted to, in round numbers, 950,000,000 barrels of some 40,000,000,000 gallons. The average depth of the wells bored in this district in 1894 was only 1260 feet, the depth having gradually increased year by year. Of the 239 wells sunk in that year the average yield was 384 barrels per day. Such a yield must truly be characterized as enormous, and while some of the wells become exhausted, others are bored from which the same tremendous outflow occurs as when the field was first tapped. If we could take into account the enormous amount of bituminous matter which has passed off in the form of natural gas in all these years in this district, the figures of output would reach such amazing proportions as to be scarcely comprehended, and make the solving of the problem as to the source of such wonderful deposits of bituminous matter, in so limited an area, still more perplexing.

The Frost and Drought of 1905.—By F. W. W. Doane, M. Can. Soc. C. E., City Engineer, Halifax, N. S.

(Read 9th April, 1906).

Frost.

The severity of the winter of 1904-5 is still fresh in the memory of the members of the Institute, and the record and effect of the heavy snowfall may be found in detail in the *Transactions* of last year. While the snowfall was extraordinary in itself the extreme severity of the winter was caused by the almost unbroken season of steady penetrating frost.

In ordinary soil in Nova Scotia a depth of two feet limits the penetration of frost; and in designing foundations for structures, footings three feet below the surface are considered safe and will rarely, if ever, be disturbed. In some other formations and under different conditions the penetration is much greater.

In Manitoba frost penetrates at times to a depth of nine feet, and in some towns water pipes are placed at a depth of eleven feet to prevent them from freezing.

In Nova Scotia the lowest temperature reported is about 30° below zero, while in Halifax the lowest record during the last forty years is 21° below in January, 1873, the next being 16° below in January, 1866.

The winter of 1903-4 was much colder than the average, the lowest temperature reached being 9° below in January and 11° below in February. The penetration was almost as great as in 1904-5, but the cold was not so continuous. The settling pond in front of the gate house at Spruce Hill lake froze, so that a man could walk over it—the first time since it was constructed, probably more than forty years ago.

In 1904-5 cold weather set in early and continued with almost unbroken severity for nearly three months. The temperature dropped in January to 7° below zero and in February to 6° below.

The penetration of frost reached a depth in some of the streets of Halifax of six feet. The unprecedented severity of the winter caused water pipes to freeze where frost had never been known before, and the usual waste was largely increased, causing a falling off in pressure on the summits and a water famine in the higher parts of the service.

Many service pipes were frozen, and after spending days and money in cutting down to the pipes and thawing them the greatest care was needed to prevent the frost from closing them again. Hydrants and mains were not immune, and the thawing operations overtaxed the staff of the water department all through the long winter. The frost penetrates more readily and to a greater depth where it can follow the water down a wall, curb-stone or pipe, consequently the pipes are sometimes frozen where the ground around them is unfrozen. The frost works down near the building and follows the pipe out under the street. When a trench or hole has been opened during the winter and refilled with frozen material, it is a difficult problem to prevent the pipes from freezing again. Frost also penetrates more readily in trenches made in rock than in closer filling. Apparatus has been provided for thawing frozen pipes in future by electricity, so that it will not be necessary to open trenches in winter and much delay, expense, annoyance and inconvenience will be avoided.

During the winter (1904-5) Barrington passage was closed by ice for about four weeks. This is a strait through which the tide rushes with a velocity of six to eight miles an hour. It has been closed twice only within the memory of the oldest inhabitant. About forty years ago this passage was frozen over so that men crossed on the ice, and about sixty years ago a load of hay drawn by oxen was taken across on the solid ice.

The writer witnessed a similar incident at Annapolis in 1888. The tide runs very swiftly opposite the town, but ice jammed in the river on the night of January 21st, and during the next thirty days steamers moored some distance down the river were loaded with apples hauled over the ice.

Governor Murray, of Rockhead prison, has kept a record for years of the date on which Bedford Basin froze over and the date on which the ice went out. February 6th was the earliest date for the closing and April 6th the latest day for the opening of this sheet of water. In 1905 it was shut up for the winter on January 24th, and remained frozen down to the Narrows until the ice broke up on April 16th.

There were ice races in the Dartmouth rink on April 3rd, and open-air skating on Milton pond, near Yarmouth, on April 5th.

The severity of the winter and the heavy snowfall chilled the water to such an extent that the lobster fishery along our shores was commenced much later than usual, and it was feared that the prosecution of this industry would be attended with but small results. Fortunately, the worst fears were not realized. The fishermen who followed this pursuit received higher prices in consequence of the conditions, and the results were even more satisfactory than in ordinary years.

Notwithstanding the lateness of the cold season, hedges were opening their leaves on May 8th, and the trees one week later.

The following table shows the lowest temperature for January and February in each year since 1864:—

1864—	January	9 below.	Febuary	4 below.
1865—	"	3 above.	"	2 above.
1866—	"	16 below.	"	12 below.
1867—	"	8 below.	"	5 below.
1868—	"	4 below.	"	7 below.
1869—	"	1 above.	"	6 above.

1870—	January	3 below.	February	4 below.
1871—	"	15 below.		
1873—	"	21 below.	"	5 above.
1874—	"	5 below.	"	zero.
1875—	"	7 below.	"	14 below.
1876—	"	1 below.	"	16 below.
1877—	"	12 below.	"	6 above.
1878—	"	3 below.	"	3 below.
1879—	"	3 below.	"	1 below.
1880—	"	9 below.	"	6 below.
1881—	"	2 below.	"	3 below.
1882—	"	12 below.	"	6 below.
1884—	"	11 below.	"	6 below.
1885—	"	9 below.	"	2 below.
1887—	"	7 below.	"	7 below.
1889—	"	6 below.	"	6 below.
1890—	"	13 below.	"	4 below.
1891—	"	2 below.	"	5 below.
1892—	"	2 above.	"	7 above.
1893—	"	2 above.	"	3 below.
1894—	"	3 below.	"	10 below.
1995—	"	2 below.	"	1 above.
1896—	"	8 below.	"	3 below.
1897—	"	5 below.	"	1 above.
1898—	"	10 below.	"	zero.
1899—	"	5 below.	"	9 below.
1900—	"	1 above.	"	2 below.
1901—	"	13 below.	"	18 above.
1902—	"	zero.	"	4 below.
1903—	"	5 below.	"	4 below.
1904—	"	9 below.	"	11 below.
1905—	"	7 below.	"	6 below.
1906—	"	2 below.	"	1 above.

Rainfall.

The amount of rainfall of any country is dependent upon the situation of the country, its position, the elevation of its hills and mountain ranges, and the prevailing direction of the winds. The influence of trees also has some effect.

The average annual rainfall in Halifax as deduced from long-continued observations covering a period of thirty-seven years, is 55.927 inches. The rainfall of 1905 was 47.795 inches—a deficiency of 8.132 inches, or 85 per cent. of the mean. There was an excess of rainfall in January, February, June, November and December, varying from 11 to 46 per cent. and a deficiency during the remaining seven months. When looked at in the dry light of statistics, the year recently ended seems to have been not unprecedented, still it was an exceptionally dry year. The number of days on which precipitation was recorded, 182, was about the average, but the total precipitation for the year was very near the minimum.

In the year 1894 the total precipitation was 45.808 inches, about two inches less than in 1905. A comparison of the two years shows, however, that at the end of November the rainfall of 1905 was slightly less than that of 1894, the difference of two inches being made in December. In fact, a study of the accompanying tables shows that the year from November 1st, 1904, to October 31st, 1905, is the driest on record, the total precipitation being only 41.685 inches or 74.5 per cent. of the mean. This minimum approaches within about two inches of the rainfall 39.51 inches reported for the year 1860, before the meteorological observatory was established. The accuracy of the latter will be accepted with less reluctance in future.

Long Lake, our great low service reservoir, was raised to overflow level by the melting of the great snows of 1904-5, and water began to run over the waste weir on the 30th of March. The lake continued to overflow until the 19th of May after which the water began to fall. It reached its lowest level on

November 4th—8 feet $4\frac{3}{4}$ inches below the waste weir. On the 16th November Spruce Hill lake was 7 feet 9 inches below the waste weir. The fall rains usually begin in September, but in 1905 the September rainfall was only 74 per cent. of the mean and October 28 per cent. Steps were taken by the city to prevent a water famine, but it was not until November 17th that fears for the efficiency of the supply were relieved. Although the rains came at last the lakes did not recover rapidly as the ground was parched, and to-day Long lake is eight inches below the waste weir, while Spruce Hill lake must rise 46 inches before it will overflow.

The season of 1905 was the driest for over ten years in the eastern States, and reports from England state that it was much below the average there.

The dryness caused much inconvenience in Halifax and was a greater strain on the water system than in 1894, because the consumption of water has increased considerably during the eleven years since the last drought. There is no danger of the low service supply running short, however, as over 1,000,000,000 gallons of water were allowed to run over the waste weir during April and May. The high service lakes were equal to the demand, although they fill up again more slowly in consequence of the comparative difference in water-sheds.

Not every engineer has the time or the opportunity to investigate in detail many points concerned in the observation of rainfall; that work appeals more to the meteorologist. It is sufficient for the engineer that he be able to obtain a trustworthy record. The writer is indebted to the meteorological agent of the Dominion government for the use of his records and valuable assistance in the compilation of the accompanying tables. The means placed at his disposal for making precipitation observations are not what they should be. He should be provided with all necessary self-recording instruments, so that a more complete record could be made and the greatest assistance given to the engineer.

The importance of possessing a reliable and complete record of rainfall appeals more strongly to the municipal engineer than to any other, because drainage and water-systems and water-power construction require for their fundamental basis a reliable record of rainfall upon which the calculations for his design may be based. In the design of drainage works the mean fall is not the conclusive fundamental datum of the engineer, not even the maximum yearly fall, but the heaviest daily fall, and, more particularly, the greatest heavy fall in a short period. The value of having such records from self-recording instruments is two-fold. First, they give an exact indication of the carrying powers of existing sewers; second, they show the demands likely to be made upon sewers and form a valuable basis upon which calculations for the improvement of existing or the design of new sewers can be based. A single gauge is not always reliable for the measurement of the rainfall in any gathering ground as instances are reported of a variation of 50 per cent. in one year where gauges were only one-quarter of a mile apart.

The following form of record would be most valuable to the municipal engineer:—

DATE.	Duration of storm.		Total precipitation in inches.	Rate per hour in inches.	20 minutes of maximum precipitation	Period of greatest precipitation.		Rate per hour. In.
	Hours	From				Hours.	From.	

The rain gauge used by the city of Halifax is of brass, cylindrical in form, with a knife-edge rim. The diameter is

$3\frac{1}{2}$ inches. This may seem a very small size for the purpose, but this question was investigated many years ago. After a long series of experiments it was found that the size of gauge or funnel made practically no difference, as gauges varying from 1 to 24 inches in diameter were used with the following results. The 24-inch gauge, being the largest, the rainfall collected therein was taken as 100, and the others were found to read as follows:—

Diameter of gauge..	1	2	4	5	6	8	12	24 in.
Reading	93	96	100	99	102	102	100	100

These results show that except in the case of very small gauges the difference in the amount of rain caught never exceeded two per cent. The adoption of a size from four inches upwards then came to be a matter of convenience, the factors which determine the size being that the instrument shall not on the one hand collect per inch of rainfall an inconveniently small, or, on the other hand, an embarrassingly large volume of water.

The city snow records at the lakes are measured on a board placed in a carefully selected location where it will be free from eddies and drifts. The board is placed level and the snow falling on it is carefully measured with a rule or scale. The depth of melted snow is ascertained by inverting a brass cylinder $3\frac{1}{2}$ inches in diameter on the board. Cylinder and board are then turned upside down so that the cylinder will contain the actual quantity of snow that has fallen within a circle $3\frac{1}{2}$ inches diameter. The snow is melted and measured in a graduated glass in the same manner as rain is measured.

The government observer does not follow the same method for snow measurement, but records the depth of melted snow as one-tenth of the depth of snow falling.

After taking a measurement the snow board is again set perfectly level and at the surface of the snow.

The selection of a site upon which to place a gauge is of primary importance. It should be placed upon a flat stretch of ground, not on the face of a slope, nor on the face of a cliff, nor on a house top. It is a mistake to place it on the top of a dam or embankment, as the accuracy of records obtained from gauges in such positions will be somewhat doubtful. Where the wind is blowing at right angles to the embankment an eddy will be set up parallel to the slope of the bank, which will have a tendency to lift the rain over the top of the bank and produce a comparatively calm area around the gauge.

The volume of rain collected decreases with the height at which the gauge is place above the ground, and experiments have been carried out from time to time to investigate the cause of this decrease. After many heated controversies over the question, it has now been established that this decrease is wholly due to the velocity of the wind and the angle which the rain makes with the horizon. Taking one foot above the ground as representing a catch of 100, at 25 feet above the ground the catch was found to equal about 79 per cent. This gives approximately the ratio of diminution of rain caught with the increase of height. If gauges are not placed at the same level above the ground much of their utility is lost, because it becomes necessary, as in the case of barometic readings, to reduce them to a fundamental level, and the application of such a correction in rainfall work is always open to a doubt. The rim of the gauge should be set perfectly level and one foot above the ground.

While the precipitation records are most valuable in computing the yield of our water-sheds, in order to determine with any degree of accuracy the percentage of rainfall collected and the run-off available for water works or power the evaporation should be determined.

The value of the rainfall for water-works or power-systems is usually determined by the average of the two or three driest years, according to the storage capacity available.

The wettest year was 1896, with a rainfall of 69.862 inches or 25 per cent. greater than the mean for 37 years (55.927 in.)

The driest year was 1894—45.808 inches or 82 per cent. of the mean.

The driest two consecutive years were 1879-80—47.835 and 52.853, an average of 50.344 inches, or 90 per cent. of the mean.

The driest three consecutive years were 1879-80-81, with an average of 50.814 or 91 per cent. of the mean.

The driest twelve months—November 1st, 1904, to November 1st, 1905, 41.685 inches, or 74.5 per cent. of the mean.

The driest twenty-four months, December 1st, 1903, to December 1st, 1905, an average of 50.060, or practically the same as for two calendar years.

The following table gives the maximum, minimum and normal rainfall for each month and for the whole year for thirty-seven years, together with the rainfall during 1905 and the departures from the normal:—

MONTH.	Year.	Maximum (inches)	Minimum (inches)	Average 1869-1905 (inches)	Rainfall 1905 (inches)	Excess or deficiency	Per cent. above or of mean.
January	1895	10.131		5.682	8.290	+2.608	46.
" ...	1896		1.720				
February ...	1870	9.780		4.769	5.326	+ .557	12.
" ...	1901		0.966				
March	1878	10.284		5.458	2.804	−2.654	51.
"	1889		2 046				
April	1889	7.403		4.000	1.260	−2.740	31.5
"	1886		0.820				
May	1886	8.819		4.025	3.217	− .808	80.
"	1903		0.676				
June	1874	7.920		3.800	4.970	+1.170	30.
"	1879		1.191				
July	1896	8.729		3.708	1.927	−1.781	52
"	1894		1 059				
August	1887	8 351		4.287	2.733	−1.554	64.
"	1899		1.542				
September ..	1896	12.092		3.747	2.753	− .994	74.
" ..	1878		0.800				
October.....	1896	15.039		5.520	1.539	−3.981	28.
"	1897		0.746				
November .	1898	10.248		5.718	6.348	+ .631	11.
"	1882		1.392				
December...	1893	10.167		5.213	6.628	+1.055	20.
" ...	1875		1.614				
Totals 1896		69.862		55.927	47.795	−8.132	85.
" 1894			45.808				

PRECIPITATION AT HALIFAX, N. S.

TABLE SHOWING THE MONTHLY AND ANNUAL DEPTH OF RAIN AND MELTED SNOW, EXPRESSED IN INCHES; ALSO THE AMOUNT THAT HAS FALLEN FROM JANUARY 1ST TO THE END OF EACH MONTH, INCLUSIVE DURING EACH YEAR.

YEAR.	January.	February.	January to February, inclusive	March.	January to March, inclusive.	April.	January to April, inclusive.	May.	January to May, inclusive.	June.	January to June, inclusive.
1869..........	4.530	4.380	8 910	7.950	16.860	2.570	19.430	5.570	25.000	3.920	28.920
1870..........	6.670	9.780	16 450	3.080	19.530	3.860	23.390	3.190	26.578	1.690	28.270
1871..........	3.730	5 880	9 610	6.160	15 770	4 880	20.650	2.590	23.240	2.960	26.200
1872..........	3.880	4.490	8.370	5.370	13 740	2 850	16.590	4.440	21.030	4.230	25.260
1873..........	7.830	1.610	9 440	4 090	13.530	2.860	16 390	2.340	18.730	2.960	21.690
1874..........	5.420	5.310	10 730	3.980	14.710	4.550	19.260	4.770	24.030	7.920	31.950
1875..........	3 481	5 877	9.378	2.113	11.491	3.378	14.869	3.977	18.846	4.067	22.913
1876..........	3.451	6.456	9.907	6.334	16.241	3.125	19.366	4 664	24 030	3.384	27.414
1877..........	4 2 0	1.809	6.009	8.666	14.675	3.801	18.476	4.024	22 500	3.841	26.341
1878..........	7 522	2 697	10.219	10.284	20.503	3.502	24.005	5.759	29 764	4.477	34.241
1879..........	4.400	3.001	7.401	6.202	13.603	3.481	17.084	4.687	21.771	1.191	22.962
1880..........	7.733	5.122	12.855	3.365	16 220	4.797	21.717	4.088	25.105	1.343	26.448
1881..........	3.607	5.329	8.936	6.556	15.492	3.498	18.990	2.460	21.450	5.308	26.751
1882..........	6.840	5.949	12.789	7.068	19.857	4.824	24.681	4.677	29.358	5.507	34 865
1883..........	4.930	3.860	8.790	4 941	13.731	3.703	17.434	8.613	26.047	3.322	29.369
1884..........	4.406	6.161	10.567	7.034	17.601	7.213	24.814	3 629	28.443	3.773	32.216
1885..........	6 388	5.090	11.478	3.889	15.367	3.520	18.887	3.282	22.169	2.749	24.918
1886..........	8.670	3.842	12.512	4.027	16.539	0.823	17.362	8.819	26 181	2.708	28.889
1887..........	7.706	6.735	14.441	4.449	18.890	6.396	25.286	2.126	27.412	2.121	29.533
1888..........	5.442	6.284	11.726	4.310	16.036	3.675	19.711	2.877	22.588	4.939	27.527
1889..........	4.391	6.181	10.572	2.046	12.618	7.403	20.021	3.871	23.892	3.755	27.647
1890..........	3.963	4 645	8.608	9 889	18.497	2.958	21.455	3.970	25.425	3.440	28.865
1891..........	8.383	8 740	17.123	2.685	19.808	4.010	23 818	4.195	28 013	4.131	32.144
1892..........	6.321	2.605	8.926	5.986	14.912	2.653	17.565	5.459	23.024	3.638	26.662
1893..........	4.781	5.979	10.760	2.303	13.063	4.209	17.272	5.054	22 326	1.753	24.079
1894..........	7.122	3.571	10.693	3 623	14.316	5.648	19 964	1.769	21.733	3.803	25.536
1895..........	10.131	4.605	14.736	5.931	20.667	3.956	24 623	4.089	28.712	1.827	30 539
1896..........	1.720	4.199	5.919	8.786	14.705	1.413	16.118	2.532	18.650	4.671	23 321
1897..........	5.896	2.898	8.794	5.470	14.264	6.211	20.475	4.613	25.088	6.070	31.158
1898..........	4.060	4.122	8.482	4.068	12.550	7.346	19.896	2.366	22.262	5.598	27.860
1899..........	5 083	3.613	8 696	7.178	15 874	3.278	19.152	3.677	22 829	3 875	26.704
1900..........	8.532	5.277	13.809	6.577	20.386	3 949	24.335	4.254	28.589	2.656	31.245
1901..........	6.043	0.966	7.009	4.102	11.111	6.318	17.429	5.556	22.985	6 959	29.944
1902..........	3.289	2.735	6.024	7.757	13.781	3.067	16.848	3.725	20.573	4.908	25.481
1903..........	5.082	3.712	8.794	7.294	16.088	5.515	21.603	0.676	22.279	3.493	25.772
1904..........	6.318	5.328	11.646	5.590	17.236	5.912	23.148	3.315	26.463	2.668	29 131
1905..........	8.299	5.326	13.616	2.804	16.420	1.260	17.680	3.217	20.897	4.970	25.867
1894..........	7.122	3.571	10,693	3.623	14.316	5.648	19.964	1.769	21.733	3.803	25.536
Average	5.682	4.769	10.451	5.458	15.909	4.000	19.909	4.025	23.934	3.800	27.734

PRECIPITATION AT HALIFAX, N. S.

TABLE SHOWING THE MONTHLY AND ANNUAL DEPTH OF RAIN AND MELTED SNOW, EXPRESSED IN INCHES; ALSO THE AMOUNT THAT HAS FALLEN FROM JANUARY 1ST TO THE END OF EACH MONTH, INCLUSIVE DURING EACH YEAR

YEAR.	July.	January to July, inclusive.	August.	January to August, inclusive.	September.	January to September, inclusive.	October.	January to October, inclusive.	November.	January to November, inclusive.	December.	Total for the Year.
1869 ..	2.920	31.840	2.580	34.420	1 570	35.990	7.300	43.290	5.470	48.760	5.770	54.530
1870 .	3.210	31.480	2.200	33.680	3.330	37.010	6.830	43.840	6.440	50.280	5.880	56.160
1871 ..	3.380	29.580	3 690	33.270	4.810	38.080	4.490	42.570	4.180	46 750	4.390	51.140
1872 ..	2.880	28.140	6.820	34.960	1.410	36.370	4.880	41.250	6.650	47.900	6.160	54.060
1873 .	3.900	25.590	4.450	30.040	4.480	34.520	8.630	43 150	7.980	51.130	4.310	55.440
1874	2.290	34.240	3.370	37.610	5.040	42.650	2.460	45 110	3.580	48.690	5.490	54.180
1875 ..	5.612	28.525	3.555	32.080	2.060	34.140	9.976	44.116	5.544	49.660	1.614	51.274
1876 ..	3.914	31 328	1.909	33.237	6.094	39.331	4.068	43.397	7.397	50.796	3.176	53.972
1877 ..	4.468	30.809	3.539	34.348	3.164	37.512	6.857	44.369	8.678	53.047	4.493	57.540
1878 ..	1.483	35.724	3.127	38.851	0.800	39.651	5 061	44.712	6.909	51.621	5.119	56.740
1879 ..	3.843	26.805	4 827	31.632	2.596	34.228	4.755	38 983	4.823	43.806	4.029	47.835
1880 ..	3.086	29.534	3.920	33.454	5.712	39.166	4.590	43.756	4.704	48.460	4.393	52.853
1881 ..	3.177	29.935	3.062	32.990	3.105	36.095	4.206	40 301	4.420	44.721	7.034	51.755
1882 ..	5.071	39.936	3.925	43.861	5.914	49.775	7.403	57.178	1.392	58.570	3 452	62.022
1883 ..	3.540	32.909	5.34	38.251	3.864	42.115	5.841	47.956	3.478	51.434	6.678	58.112
1884 ..	8.294	40.510	2.771	43 281	1.788	45.069	3.093	48.162	5.992	54.154	9.124	63.278
1885 ..	5.817	30.735	3.001	33.736	2.497	36.233	6.280	42.513	5.423	47.936	8.693	56.629
1886 ..	6.525	35.414	4.526	39.940	4.459	44.399	2.135	46.534	5.284	51.818	5.469	57.287
1887 ..	2.045	31.578	8 351	39.929	3.308	43.237	3.058	46.295	6.718	53.013	4.120	57.133
1888 ..	5.001	32.528	7.000	39.528	5 331	44.859	6.859	51.718	6.802	58.520	7.774	66.294
1889 ..	2.668	30.315	2.633	32.948	1.399	34.347	4.179	38.526	7.145	45.671	2.988	48.659
1890 ..	2.141	31.006	7.042	38.048	4.534	42.582	6.603	49.185	3.716	52.901	7.202	60.103
1891 ..	4.003	36.147	3.385	39.532	3.052	42.584	9.621	52.205	2.388	54 593	4.076	58.669
1892 ..	2.710	29.372	6.809	36.181	1.744	37.925	3.472	41.397	9.240	50.637	3.053	53.690
1893 ..	4.757	28.836	5.954	34 790	4.391	39.181	5.640	44.821	3.760	48.581	10.167	58.748
1894 ..	1.059	26.595	3.993	30.588	1 010	31.598	3.863	35.461	5.785	41.246	4.562	45 808
1895 ..	3.924	34.463	5.5 2	39.965	2.491	42.456	5.627	48.083	8.223	56.306	5.846	62.152
1896 ..	8.729	32.050	3.037	35.087	12.092	47.179	15.039	62.218	4.396	66.614	3 248	69.862
1897 ..	3.661	34.819	5.185	40.004	1.169	41.173	0.746	41.919	6.051	47.970	3.552	51.522
1898 ..	3.652	31 512	5.651	37.163	4.158	41.321	4.845	46 166	10.248	56.414	4.066	60.480
1899 ..	5.747	32.451	1.542	33.993	3.201	37.194	6.191	43.385	4.590	47.975	5.038	53 013
1900 ..	1.872	33.117	3.993	37.110	5.013	42.153	7.365	49.518	6 858	56.376	3.321	59.697
1901 ..	1.585	31.529	3 656	35.185	6.872	42.057	4.906	46.963	2 560	49.523	8 573	58 096
1902 ..	1.651	27.132	4.767	31.899	4.657	36.556	4.252	40.808	3.813	44.621	7.295	51.916
1903 ..	4 313	30.085	4.247	34.332	4.237	38.569	6.368	44.937	9.598	54.535	4.590	59 125
1904 ..	2.323	31.454	6.511	37.965	4.502	42.467	5.031	47.498	5 007	52.605	4.859	57.194
1905 ..	1.927	27.794	2.733	30.527	2.753	33.280	1.539	34.819	6.348	44.167	6.268	47.435
1894 ..	1.059	26.595	3.993	30.588	1.010	31.598	3.863	35.461	5.785	41 246	4.562	45 808
Aver..	3 708	31.442	4.287	35.729	3.747	39.476	5 520	44.996	5.718	50.714	5 213	55.927

PRECIPITATION AT HALIFAX, N. S., 1905.

TABLE COMPILED FROM RETURNS OF DOMINION GOVERNMENT METEOROLOGICAL AGENT, SHOWING DEPTH OF RAINFALL AND MELTED SNOW IN INCHES AND DURATION OF EACH STORM IN HOURS. (T=trace.)

Day of Month.	January.		February.		March.		April.		May.		June.	
	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.
1	1.0	.050	....	....	6.2	.470	....	......	3.3	.298	....	......
2	3.0	.020	....	......	....	.. .	1.3	T	1.0	.154	6.0	.925
3	9.0	.334	1.0	.010	....	......	6.0	.020	2.7	.082	1.0	.054
4	13.5	2.128	....	......	.3	T	...	.....	11.6	.704	....	......
5	.3	T	....	......	.5	T	2.0	.027	....	......	....	.....
6	....	......	3.0	.030	11.0	.240	19.5	.258	1.0	.020	8.0	1.681
7	1.8	.184	8.2	.390	....	.....	9.0	.136	10.0	.332	....	.....
8	5.0	.592	2.5	.040	15.5	.634	....	....	....	.....	6.8	.328
9	.1	T	....	......	4.7	.300	....	......	4.6	.467	....	......
10	4.3	.325	6.0	.220	12.8	.402	3.0	.034	2.5	.058	1.0	.038
11	....	......	.8	.020	....	......	2.5	.032	....	......	....	.....
12	10.5	.880	....	......	....	....	6.0	.128	....	......	.8	.032
13	3.0	.190	10.0	.958	....	....	...	....	....	.....	15.2	.452
14	....	......	1.0	.048	....	......	1.0	.062	.4	T	....	T
15	....	......	1.0	.020	....	....	....	.....	.3	T	...	......
16	....	.....	17.7	1.870	....	......	....	......	.4	T	....	T
17	2.0	0.60	1.8	.020	....	.....	....	T	7.0	.082	.5	.010
18	....	......	2.5	.090	....	....	...	......	9.3	.270	10.5	.696
19	2.2	.067	....	.....	2.0	.080	....	....	....	.. .	....	.....
20	....	.....	1.8	.040	2.5	.030	....	....	4.0	.090	....	......
21	....	......	1.8	.110	....	...	2 9	.056	.5	T	3.7	.054
22	.50	T	....	.....	....	...	5.3	.253	....	.....	7.5	.048
23	6.8	.820	7.5	.440	....	.....	.5	T	....	.....	5.5	.010
24	....	....	10.0	.140	....	.....	....	.....	....	.....	....	......
25	5.0	.420	13.0	.270	....	......	.5	.010	....	......	2.0	.010
26	18.0	1.180	....	......	2.0	.120	....	......	....	....	8.5	.268
27	3.5	.140	5.5	.580	2.5	.090	....	......	2.2	.036	12.0	.270
28	1.8	.020	1.6	.030	10.3	.426	....	.....	3.6	.392	7.8	.082
29	5.0	.100	...	......	.5	.012	9.5	.144	.5	.010	1.0	.012
30	....	.....	....	......	....	.....	4.8	.100	4.5	.222	....	......
31	18.0	.780	..	.....	....	......	....	......	....	.....	....	.....
	....	8.290	....	5.326	....	2.804	....	1.260	....	3.217	....	4.970

PRECIPITATION AT HALIFAX, N. S., 1905

TABLE COMPILED FROM RETURNS OF DOMINION GOVERNMENT METEOROLIGICAL AGENT, SHOWING DEPTH OF RAINFALL AND MELTED SNOW IN INCHES AND DURATION OF EACH STORM IN HOURS. (T=trace.)

Day of Month.	July.		August.		September		October.		November		December.	
	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.	Hours.	Inches.
1	....	......	2.8	.028	....	......	....	......	7.0	.460	....	......
2	....	......	13.5	.315	....	......	....	......	1.5	.185	....	.328
3	13.8	.436	....	......	....	......	....	......	....	......	....	1.086
4	.5	.011	....	......	12.6	1.116	....	......	2.5	.048	....	T
5	....	......	....	......	6.0	.558	....	......	4.5	.608	....	......
6	....	T	4.5	.372	4.7	.134	.3	T	....	......	....	......
7	....	......	2.5	.986	5.3	.182	....	......	8.2	.732	....	T
8	....	......	....	......	....	......	....	......	.5	T	....	......
9	....	......	....	......	....	......	....	......	1.4	.098	....	2 380
10	....	......	1.5	.061	....	......	....	......	....	......	....	034
11	....	......	....	......	....	......	....	......	....	......	....	......
12	....	......	8	.028	....	......	....	......	.3	T	....	.396
13	.5	T	.7	.020	4.5	.228	3.1	.188	....	......	....	.010
14	....	......	....	......	2.0	.126	....	......	2.0	.040	....	......
15	2.5	160	....	......	....	......	....	......	....	......	....	......
16	....	......	13.8	.426	2.0	.035	....	......	6.5	.172	....	......
17	4.8	.088	....	......	....	......	....	......	19.3	1.803	....	......
18	3.2	.052	....	......	5.2	.072	....	......	....	......	....	.428
19	....	......	....	......	2.0	.028	8.6	.184	....	......	....	......
20	....	......	7.3	.165	11.5	.236	13.0	.728	....	......	....	......
21	....	......	....	......	1.0	.038	2.8	.071	....	......	....	.100
22	....	......	....	......	....	......	....	......	....	......	....	.822
23	....	......	1.0	.312	....	......	....	......	....	......	....	.046
24	.1	T	....	......	....	......	....	......	....	......	....	108
25	.2	T	....	......	.2	T	4.0	.368	6.8	.010	....	......
26	....	......	....	......	.1	T	....	......	....	......	....	......
27	.5	034	....	......	....	......	....	......	3 5	.112	....	......
28	.1	T	.3	T	....	......	....	......	1.5	.020	....	T
29	....	......	....	......	....	......	....	......	17.0	1.488	....	.392
30	....	......	.3	.020	....	......	....	......	5.5	.572	....	.498
31	13.5	1.146	....	......	....	......	....	......	....	......	....	T
	....	1.927	....	2.733	....	2.753	....	1.539	....	6.348	....	6 628

PRECIPITATION AT HALIFAX, N. S.

TABLE SHOWING THE NUMBER OF TIMES THAT THE TOTAL PRECIPITATION, EACH DAY FROM 1894 TO 1905, INCLUSIVE, HAS BEEN NEAREST TO A SERIES OF AMOUNTS RANGING FROM ONE-HUNDREDTH OF AN INCH TO FOUR AND A HALF INCHES.

YEAR.	QUANTITY IN INCHES.																									Total Rainfall for the Year.	YEAR.
	$\frac{1}{100}$	$\frac{1}{10}$	$\frac{2}{10}$	$\frac{3}{10}$	$\frac{4}{10}$	$\frac{5}{10}$	$\frac{6}{10}$	$\frac{7}{10}$	$\frac{8}{10}$	$\frac{9}{10}$	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$		
1894	50	42	13	16	9	7	5	5	5	6	2	2	2	...	...	...	...	...	1	...	...	...	...	...	...	45.808	1894
1895	33	31	23	14	10	6	4	10	7	1	8	5	3	2	...	2	...	...	...	...	...	...	...	...	...	62.152	1895
1896	45	30	19	12	10	8	5	7	6	3	2	3	6	1	...	...	1	...	...	1	1	...	1	...	1	69 862	1896
1897	48	54	15	16	7	11	6	4	2	5	3	4	1	1	...	...	...	...	1	...	...	...	...	...	...	51 522	1897
1898	46	34	20	17	14	9	6	6	6	4	3	8	2	...	...	1	...	1	...	...	...	...	...	...	...	60.480	1898
1899	49	23	16	7	5	7	7	5	8	5	3	5	3	1	...	1	...	1	...	...	...	...	...	...	...	53.013	1899
1900	38	47	18	13	12	6	12	4	2	6	5	5	2	2	1	1	...	...	...	...	...	...	...	...	...	59.697	1900
1901	56	41	11	18	8	4	2	3	4	1	5	5	4	2	2	1	...	...	1	...	...	...	1	...	...	58.096	1901
1902	46	44	17	20	15	5	3	7	5	3	4	2	2	1	...	1	...	...	1	...	...	...	...	...	...	51.916	1902
1903	38	24	23	24	9	10	5	6	3	2	4	3	2	3	3	...	...	1	...	...	...	...	...	...	...	59.125	1903
1904	37	36	20	18	10	8	6	6	4	3	4	5	2	1	3	...	1	...	...	...	...	...	...	...	...	57.194	1904
1905	44	35	15	15	13	5	6	4	3	2	4	2	1	2	2	...	1	...	...	...	...	...	...	...	...	47.795	1905
Totals	530	441	210	190	122	86	67	67	55	41	47	49	30	16	11	7	3	3	4	1	1	...	2	...	1	676 660	Totals.
Means	44	37	17	16	10	7	5.6	5.6	4.6	3.4	4	4	2.5	1.3	1	.6	25	.25	3	.1	.1	...	.17	...	.1	56.388	Means.

QUANTITY OF WATER DISCHARGED OVER LONG LAKE WASTE-WEIR IN GALLONS.

YEAR.	January.	February.	March.	April.	May.	June.	July.	August	Septemb'r	October.	Novemb'r	December	Total.	Precipitation in inches.	No. of days Rain or Snow fall.
1892	211,226,360	....	241,903,243	57,186,763	84,085,451	17,123,963	12,381,389	55,196,703	5,831,022	....	229,960,879	95,307,034	1,010,202,807	53.690	.....
1893	982,576	60,758,585	....	332,062,217	173,923,963	....	....	....	....	....	....	521,481,528	1,089,208,879	58.740	.....
1894	17,198,557	118,639,579	189,455,675	582,602,480	12,516,049	....	....	....	....	....	....	....	920,412,340	45.808	166
1895	187,238,515	15,399,804	104,959,943	398,219,715	7,042,134	2,779,621	....	....	....	....	....	199,308,252	924,947,384	62.152	161
1866	10,639,329	....	495,949 894	78,609,225	....	....	....	....	412 374,620	1,015,458,665	80,678 961	49,409,208	2,173,119,902	69.862	183
1897	101,190,514	....	88,923,753	447,206,304	120,165,769	96,958,138	13 240,719	....	....	....	....	....	867,685,197	51.522	193
1898	....	....	38,354,174	681,939,737	62,736,359	224,848,481	....	5,088,822	....	48,802,036	758,002,940	233,351,627	2,053,124,176	60.480	196
1899	261,355,317	....	305,513,150	682,500,339	98 583,572	26,698,635	....	....	....	....	44,555,834	103,361,274	1,524,568,121	53.013	169
1900	73,591,939	643,645,456	744,897,071	416,994 078	103,136,002	....	....	....	....	....	....	....	2,282,267,546	59.697	198
1901	163,528,558	11,417 228	142,220,672	723,579,284	99,238,010	227,294,520	725,898	....	....	....	....	108,307,998	1,179,312,168	58.096	195
1902	238,435,990	....	664,586,695	184 352,747	....	....	....	....	....	....	....	10,665,474	1,098,040,906	51.916	188
1903	171,178,014	....	456,210,407	524,039,759	....	....	....	....	....	....	161,989,078	337,810,982	1,651,228,240	59.125	179
1904	54,293,952	23,023,128	402,429,789	568,754,199	112,990,817	7,877,994	....	....	....	....	....	....	1,169,370 179	57.194	196
1905	....	....	43,832,254	914,509,990	113,896 013	....	....	....	....	....	....	....	1,072,238,257	47.795	182
Avg	106,704,473	62,563,149	279,945,480	470,894,774	92,022.438	43,041,482	1,882,000	4,306,109	29 871,832	78,161,479	91,084,835	118,500,242	1 378,980,436	56.364	184

EELS IN WATER PIPES AND THEIR MIGRATION.—BY WATSON L. BISHOP, Superintendent of the Dartmouth Water Works, Halifax Co., Nova Scotia.

(Read 9th. April, 1906.)

The early history of the eel (*Anguilla vulgaris*) is involved in mystery. No other common fish has so completely baffled scientific investigators. The Greek poets jocosely remarked "that since all children whose paternity was doubtful were ascribed to Jupiter, he must be considered the progenitor of the eel." Aristotle emphatically stated that eels are spontaneously produced from the mud and moist earth. About sixty years ago, Martens, a famous naturalist stated, "Among all the animals that surround us, the eel is the only one which has never unveiled the secret of its propagation, even to the most perservering investigators." From that time to the present the most persistent efforts have been made to solve the mystery of the sexual characteristics of this fish and its reproduction.

In 1896, G. B. Grassi, a professor in Rome, after four years devoted exclusively to the study of this fish, and years of previous inquiry, communicated a paper to the Royal Society of London, which practically solved this mystery. He established the fact that the eel reproduced itself only in very deep water, at least 1500 feet in depth; that the eggs deposited, float there in these great depths; that the young when hatched take a form not recognized previously as the young of the eel, but described under the name *Leptocephalus brevirostris*, which proves to be its larval form; that this fish passes through a metamorphosis in a few weeks, and then becomes the eel known to all when about two inches in length; that in a very short time it seeks the fresh water to acquire sexual maturity and go on with the work of reproduction; that the parent eel then dies, and

therefore the mature eel never returns again to the fresh water. He also shows with others, that the female eel grows to a much greater size than the male eel, while the latter rarely exceeds a foot or fourteen inches in length, although the female frequently attains a length of six feet, and a weight of from twelve to fifteen pounds.

The fact that the eel has to seek such great depths in the open ocean in order to become sexually developed, and has to remove itself far from the usual haunts of man, and the further facts that special ships and apparatus had to be fitted out for its capture, and that but very few localities on the globe are available for the study of the mature fish and its young, were the causes which prevented scientists from learning sooner the secrets of its life history.

As there is still a great deal left to be learned, from the fact that this fish is noctural and secretive in its habit, I thought it might be of some interest to place before you the result of some investigations I have made during the past few years regarding its habits.

Since the water system was installed in Dartmouth in 1892, until 1904, eels caused considerable trouble by getting into the main pipe at the intake, and thence finding their way through the mains to the service pipes in the town, and plugging them up. The lakes from which we draw our supply are about eight miles from the sea by following the stream. This stream passes through other small lakes before reaching the salt water.

The time of year when eels gave us most trouble was during the months of September and October. At this season men were constantly employed in digging up the service pipes to take out these obstructions. It almost invariably happened that the services which were troubled most by them were the ones having leaky fixtures. The eel imprisoned in the pipes would be constantly feeling for any current whereby it might escape, and would thus get into the services. Digging up so many pipes being so expensive, and also damaging to a well finished

street surface, as well as being annoying to householders, I eventually discovered a plan which proved more satisfactory and economical. I found that by attaching a strong pump to the service pipe into the house, by means of which the eel could be easily forced back into the main, (which we frequently did against a pressure of 90 pounds), the eel being dead, or nearly so, was easily carried along with the current and taken out of a hydrant opened for this purpose. It was sometimes necessary to shut a valve to divert the flow of water in the direction of the hydrant.

During the above-mentioned migatory season, there had been no water going over the waste weir. The only water going from the lakes was by way of the water pipes. From the above facts, and from noting that after heavy rains occurred, many eels would be taken from the water pipes, I came to the conclusion that at such times they must gather about the intake in great numbers, trying to follow the current of the water to reach the sea.

The water enters the screen-chamber through an opening two feet wide by nine feet deep. In this opening three screens were placed one above the other. In the bottom screen, which is two by three feet, I cut in the centre a hole sixteen inches in diameter and fitted to it a funnel-shaped intake of screen cloth, 8 by 8 mesh, No. 16 wire, leaving a circular opening of one and a half inches to admit eels. I then boxed off the back of the screen with the same material. It can be readily seen that eels trying to follow the flow of water would easily find their way into this trap, from which there is no escape except through the small funnel opening by which they came in. The peculiar construction of this trap makes this opening very difficult to find from the inside; therefore, eels one in, remain there until they are taken out.

The trap was put in position on the 29th of April, 1904, and on May 6th eighty-nine eels were found in it. Three were about one foot long, the remaining eight-six were small, from

four to eight inches in length, the average length being 5.96 inches.

May 13th, forty-four were taken. The four largest were about one foot, while the remainder were small, similar to the ones taken the week before.

May 30th, sixty-one were caught. Two of these were large, being about eighteen inches long, the others were small like the ones previously taken.

June 17th, twelve were caught; seven of which were small, and five quite large.

June 29th, the trap was empty.

July 19th, thirty-six were in the trap. Two were small, the others quite large.

August 5th, twenty-three were caught, measuring from twelve to eighteen inches in length.

August 19th, fifty-one were caught; all were the size of those taken from the service pipes, about one foot long.

August 26th, three hundred and eight eels were found in the trap, ranging in length from twelve to fourteen inches, except two which were much larger. By referring to the precipitation of that year it will be seen that on the 21st the rainfall was 2.44 inches, and on the 23rd 0.43 of an inch.

September	2nd,	11	were	taken.
"	8th,	23	"	"
"	16th,	41	"	"
"	23rd,	2	"	"
October	5th,	22	"	"
"	14th,	46	"	"
"	21st,	0	"	"
"	28th,	2	"	"

The trap was then taken out, the migratory season being over, with a total catch of seven hundred and eighty.

After the large catch on August 26th, as shown by the above data, few had found their way into the trap for several days.

It is likely, therefore, that nearly all the eels in the vicinity of the trap were caught, and that they were scarce about the gate-house until the few which were not in the first run had found their way to the intake. It has also been shown that nearly all the eels taken in the early spring were small, probably one year old, and during their earlier life had remained in the lakes nearer the sea.

The lakes in question being so far from the sea, and the outlet from them passing through other lakes in its course, it does not appear necessary that they should make the entire journey the first year.

What confirms me in this belief is, that several years ago I saw during the spring, at the head of the tide waters of the Cornwallis river, in King's County, N. S., many thousands of small eels working their way up the stream in the shallow water at each side of the river. These were certainly not more than two and a half to three inches long. To form an idea of the great numbers passing along I judged that there was one hundred or perhaps more in a space of two feet.

This stream of eels was continuous without a break as far as they could be seen each way. It can readily be seen that vast quantities were finding their way to the spacious still waters in the meadows about half a mile further up the stream. Unfortunately, I cannot give the exact date on which this observation was made.

I am of the opinion that the first catches in the spring, which were nearly all of small size, had just reached the lake by way of the stream, and being naturally somewhat tired, had settled in the deep water to rest, and had thus found their way into the trap at the intake which was only about one hundred feet from where they entered the lake. A subsequent experiment, which is explained later, proved the foregoing assumption to be correct.

On April 19th, 1905, the eel trap was again put in place in the gate-house, and when visited on May 9th it contained one

hundred and twenty-three small eels, the same size as the ones taken in the early spring of the previous year. On this date, May 9th, I also put a trap in the overflow with the opening facing down stream to intercept eels that might be coming up into the lake.

May 17th this trap was examined and found to contain eighty-nine small eels, thirteen small trout, one small sucker, and one minnow. On the same date only eighteen small eels were taken from the trap in the gate-house.

June 1st sixty-six small eels, ten small trout, and four suckers were taken from the trap in the overflow, and only 9 small eels were in the trap in the gate-house. This proves in two ways that my theory was correct, and that the small eels taken in the early spring of 1904 had just reached the lake. A confirmation is found in the fact that while the two traps were in use, the trap in the stream stopped nearly all that were going into the lake, so that there were only a few to get into the trap in the gate-house.

The trap in the overflow stream was taken out June 1st, 1905.

June 9th, six eels were in the trap in the gate-house;

June	24th,	2	were	taken.	Oct.	6th,	5	were	taken.
July	1st,	2	"	"	"	12th,	0	"	"
"	14th,	1	was	"	"	21st,	23	"	"
"	24th,	14	were	"	"	28th,	4	"	"
"	29th,	0	"	"	Nov.	4th,	6	"	"
Aug.	5th,	5	"	"	"	10th,	0	"	"
"	15th,	22	"	"	"	18th,	7	"	"
"	24th,	9	"	"	"	25th,	0	"	"
Sept.	1st,	9	"	"	"	30th,	3	"	"
"	7th,	50	"	"	Dec.	7th,	1	was	"
"	19th,	19	"	"	"	18th,	0	were	"
"	26th,	12	"	"					

On December 27th no eels were found and I took the trap out, the lake being then frozen over. The trap was kept in

several week later than the previous year. The autumn (the migratory season for eels) being unusually dry, they did not seem to be moving as in the previous year. The trap was therefore kept in to find whether they would migrate when sufficient rain had fallen to raise the lakes and streams. The rain held off, however, until about the middle of November, and it was then so late there was no noticeable movement of the eels.

Many water-works men have held that the way eels get into the water pipes is by getting through the screens when very small, and that they live in the pipes until they are about a foot long and then they find their way into the services. I cannot credit this, as they would then be giving trouble all the year round, and would not get in the pipes periodically as they now do. It has also been pointed out that if an overhanging dam were put across the stream the small eels could not reach the lake, and in a few years there would be no small eels in the lakes to get in the water pipes. This idea seems quite reasonable, but I do not think it complete enough to be entirely successful. I think the ends of the dam should be arranged so as to prevent eels passing around the end of the dam on the land, and thus reaching the stream above.

That eels are well able to pass around or over a dam, there can be no doubt. I tried an experiment with one lot taken from the trap with the following results: They were put in a box without water, and kept in a room where the temperature was fifty-six degrees (Farenheit), and at the end of twenty-seven hours two were put in water and soon became lively, and appeared as well as though they had never been taken from the lake. The others appeared to be in about the same condition. The largest one lived forty-three hours. Other experiments tried later in the summer proved that eels fifteen to eighteen inches long, will live longer than small ones. In one case I had one to live out of water for seventy-two hours.

Judging from these facts, these fish can leave the water in the night while the grass is wet with dew or rain, and remain

out of water for several hours without any inconvenience. As they can move through wet grass very readily, it is therefore evident that they can travel overland for considerable distances should occasion require it.

What would likely be the most effectual way to prevent them from getting into the lakes, would be to put lime in the stream every evening, commencing in the spring as soon as the stream is free from ice, and continuing until the migratory season is over. It is a well known fact that eels have a great dislike for lime, and it is not at all likely they would enter a stream where the water was charged with it. Lime is often used in earth dams to prevent eels from boring through and thus causing leaks or washouts.

I expect to continue catching eels both at the intake and in the overflow stream, to determine whether their numbers will be lessened in the lake, and if by taking the small ones on their way to the lake, it will decrease their numbers returning to the sea in the autumn.

Since the trap has been in use, there have only been two or three eels taken from the service pipes each year; whereas, in former years, from thirty to fifty were taken out of the water pipes each autumn during the downward migratory season. This proves conclusively that the work for which it was intended, that is, to catch the eels at the intake and thus prevent them from entering the water-mains, has been successfully accomplished by the trap.

In conclusion, I find that this troublesome fish goes up streams in the spring months in large numbers, and that during the autumn the mature fish returns to the sea. During the summer months a few are caught in the trap, but I attribute this to accident instead of migration. The eels are simply feeding around or looking for a dark spot in which to hide during the day, and thus get entrapped.

That they can be effectually stopped from getting into the service pipes is certain if sufficient care is taken.

Whether or not the quality of the water will be affected adversely by keeping all the eels out of the lake is to me an open question. The eel is well known to be a great scavenger ; but on this subject I have not secured sufficient data to form an opinion.

Discussion.

F. W. W. Doane.—The eel nuisance has been a most perplexing problem for every superintendent of a water system. It is at times very difficult to account for their presence in pipes. There is no doubt in the mind of the writer that eels will climb over a screen projecting from eighteen inches to two feet above the water. Traces of eels have been noted on the top of the screens in the gate-houses, and on one occasion an eel was caught in an effort to surmount the obstructing screens. The carelessness of a gate-keeper sometimes permits their entrance through a small hole worn or torn in the screen or where the corner of the screen frame unprotected by metal has become worn. In the Halifax screen chambers there are two sets of grooves for screens separated only by a thin angle-iron. It was suspected that eels got in while the screens were being changed, consequently a batten was placed on the back of the lower front screen at the bottom edge so that the space between the two sets of screens was completely filled. By always putting in the new screens before removing the old set, there is no opportunity for eels to get between them.

Anguilla vulgaris is supposed to be long lived, one authentic instance being recorded of an eel which was at least thirty-one years old.

There is no doubt of the ability of eels to travel over land. On more than one occasion Halifax water department officials have seen them, when thrown out of a trench or stream (near the lakes), start for the lake.

When migrating, no ordinary obstacle seems to stop them. It is claimed that they have been known to cross from one water to another by ascending a branch of a tree hanging in the water

and dropping on the other side. They have been known to climb steep ascents also.

It is probable that the migration down stream is made at night, dark nights being chosen, and moonlight being sufficient to stop them. The young eels going up in the spring travel by day.

It is claimed that eels are peculiarly averse to cold, and that the temperature of the brackish water of estuaries is always higher than that of unmixed salt or fresh water. Eels bury themselves in winter a foot or more in the mud near the outlet of a stream, and are taken with a spear. It is uncertain whether such eels spend the summer in salt or fresh water. To the ordinary observer there is little difference in appearance between the eels taken during the summer in salt water and those taken from the lakes.

On one occasion eels filled a main on Granville Street, Halifax, so completely that when the pipe was cut it became necessary to make an auger to bore the pipe out.

The result of Mr. Bishop's study and experiments is most interesting, and further work will add equally valuable information. A better acquaintance with the habits of eels will be the means of saving much money and annoyance, and may enable superintendents to prevent entirely the entrance of eels to the pipes of water systems.

R. H. Brown.—At Sydney Mines, Cape Breton, some years ago, we made a reservoir by closing the culvert in an embankment on the colliery railway. The dry valley thus closed was converted into a lake of a few acres in extent and some ten feet deep at the middle. Its source of water supply was the drainage of the fields on the surrounding slopes, and its only outlet was by pipes of four inches diameter and about two thousand seven hundred yards in length, which conducted the water from this reservoir to the colliery engines at the Princess pits. After a few years eels were found in the pipes obstructing the flow of

water. The eels taken out were of usually good ordinary size; but on one occasion when we found the water completely stopped at a certain point, we had to break a pipe there, and found in it a living eel of about four inches in diameter (the full size of the pipe) and between three feet six inches and four feet long. The eels had no possible waterway by which to get into our reservoir, but must have travelled overland for about half a mile from a brook that runs into the Big pond. The Big pond, in which eels were plentiful, was a salt-water lake, having connection with the sea by a channel through a sand bar. These eels on their way had to pass over the railway embankment, above mentioned.

The eels in Cape Breton do not seem to migrate; they are seen in abundance, both in summer and in winter, in all the lagoons and estuaries around the coast and in the Bras d'Or lake. In summer they move about among the long eel-grass looking for food, and in winter they lie dormant in the mud in the same localities.

I once in July was watching a large shoal of smelts entering the barrasois at Indian brook, near St. Ann's, C. B., and noticed a number of large eels passing along among them. At frequent intervals an eel would be seen to turn quickly and bite a smelt; the latter at once turned on its side and floated helplessly down the channel followed by the eel, who, I presume, devoured it at his leisure.

Water Powers on the Mersey River, N. S.—By W. G. Yorston, C. E., City Engineer, Sydney, N. S.

(Read 21st. May 1906.)

The province of Nova Scotia is the second smallest of the provinces composing the Dominion of Canada. It comprises about 21,000 square miles of territory in a shape of a rather narrow peninsula about 350 miles in extreme length, and with an average width of less than 100 miles. Owing to its shape the province cannot boast of any very large rivers, but in some of those rivers that we do possess nature has placed in our hands rather valuable forces, which have up to the present time been only partially made use of, partly from the lack of purpose to apply the power to. The resources of the province are rich and varied, and it is especially rich in its mines and minerals. In the last few years a rapid development has taken place in Nova Scotia, and in the course of such development the question of power has naturally forced itself to the front, cheap power being essential to the successful operation of large factories, or even to the mining of any kind of mineral. My own belief is that the development of the resources of the provinces is only beginning, and in a few years time great strides will be taken in the opening up of resources that have already lain for too great a time undeveloped. Believing that such is the case, the question of cheap power becomes at once a large and important consideration, and it is safe to predict that before very long every availbale water-power of any size in the province will be producing energy for the operation of factories and other purposes for which power is required.

Our neighbours in the south have for many years recognized the value of their water-powers in connection with the development of the country, and have created a special depart-

ment with the object of measuring and tabulating the quantity of flow of all the principal streams of the country. This engineering department, which is called the Hydrography Division of the Geological Survey, embraces among its members many of the best well known and foremost men in the profession. They have already accomplished very much, and the statistics gathered as to the flow of streams, the evaporation from water surfaces, etc., are found to be invaluable. Data such as are collected by this corps of men are of great value, as the researches cover a period of time long enough to determine beyond doubt that the results given are correct in every detail, and that they can be absolutely relied on.

In making an estimate of a water-power it is essential that accurate information be had on the following points:—

(1), The flow of the stream, both maximum and minimum.

(2), The total fall at the power site selected.

(3), The practicability of providing storage.

(4), A record of the periods of drought.

The flow of the stream is the one thing most apt to be overestimated, for with a knowledge of a stream covering only a short period of time it seems to be a most natural thing to forget that the minimum or dry summer flow is only a fraction of the average flow of the stream, and consequently if a mistake is made in designing or construction of a water-power it is generally an over-estimate of the power to be derived from the plant installed. Up to the present time no such data regarding stream flow of any kind for Canadian streams have been collected, but I have no doubt but that in the near future the rapid development of the country will lead the government to undertake a work which would lead so directly to the further employment of capital and tend to increased prosperity.

Of Nova Scotia rivers the Mersey is probably the largest, and it is certainly the one best adapted for the development of

water-powers. The main source of the river is in Annapolis county, approximately 15 miles from the Bay of Fundy. Branches to the main stream also come from the counties of Shelburne and Digby. The extent of territory drained by the river is 600 square miles, and on the water-shed are to be found many lakes of large size, of which Rossignol, which has an area of 18 square miles, is the largest. In all, about 40 square miles of lakes are drained by the Mersey, and consequently the river is much more steady in its flow than others of our rivers, due to the large area of lake surface on its water-shed. It will readily be seen that this steadiness of flow particularly adapts this river for the development of water-powers, but after all, the chief recommendation of the Mersey river is the fact that in the last sixteen miles of its length it has a total fall of 260 feet. The river for this portion of its length is really a succession of many rapids or falls, and as the high ground approaches close to the river, on both banks there are many good power sites to be found, capable of development at a comparatively low cost. The portion of the Mersey river which I speak of as being specially adapted for water-powers, is the last sixteen miles of its length, from the point where it leaves the lake (known as Indian Gardens) down to tide water, and I intend giving a short description of the water-powers already developed on this portion, as well as the possibilities of the further development and its application to industries particularly suited to the locality.

In the early days the Mersey river was used by the Indians as a means of communication with the Atlantic coast. The route followed was up the Lequille river to its source in a lake about 14 miles back, and thence by a short portage of about one mile to the head waters of the Mersey, from which point it was comparatively easy to descend by canoe to the ocean at the mouth of the Mersey. That this route was used extensively by the Indians there is abundant evidence in the relics to be found on the shores of some of the lakes on the river, and

guides will now point out what are known as the "picture rocks," so named because of the rude Indian drawings made with some hard tool on the flat surface of the rocks on the shore of "Kidjmie Kidjic" or Fairy lake.

The water-shed of the Mersey is covered with a good growth of nearly every variety of our native trees, and the many branches of the river afforded such an easy mode of transporting the logs that lumbering operations on the river have always been prosecuted with vigor since the days of early settlement, and up to the year 1893 this was practically the only use made of the splendid water-powers on this river. As the great consideration of the owners of saw mills was to deliver the sawn lumber as near navigable tide water as possible, and as the quantity of power required was not large, they were content to utilize heads of 8 to 10 feet, and leave the larger power developments for the future. Accordingly the saw mills were built on two dams about one mile apart, the lower dam being situated just above the tide water at Milton Falls, about $2\frac{1}{4}$ miles above the town of Liverpool, from which place the lumber has always been shipped.

In the year 1883 an engineer named Emil Vossnack, made surveys and plans for the development of the water-power at two sites immediately above the flowage of the Potanoc or upper saw-mill dam. His purpose was to construct two dams, one at Cowie's Falls, and another at the head of Rapid Falls, and his estimate of the power to be obtained from both was 10,000 horse-power. A company was organized in London to undertake the construction of the two dams, and the necessary mill buldings, etc., for the manufacture of pulp and paper. This company acquired all the necessary lands, etc., for the construction of its dams and factories, but for some reason construction was never started, and nothing further was done until the year 1893, when the Acadia Pulp and Paper Company, recognizing the very cheap power to be got, and the great possibilities of its adaption to the manufacture of

mechanical pulp, acquired the rights of the old company, and commenced the building of a pulp mill at the Rapid Falls site. In the year 1900 the same company extended their operations by building a second dam and mill at Cowie's Falls, immediately below the first one.

For the purpose of supplying power to generate electric current for its lighting system, and motive power for manufacturies, the town of Liverpool in 1903 acquired the water-power on the river immediately above the Acadia Pulp Company's property at the falls known as "the Guzzle," and have constructed an up-to-date electric plant operated under a 20 foot head. This plant owned by the town was a much more costly plant to develop than those below it on the river, as the dam and power-house are over three-quarters of a mile apart, still even with the heavy cost of construction, the cost of power to the town of Liverpool per horse-power is comparatively light, and the town is operating a successful and up-to-date plant.

I give below a short description of the water-powers at present on the river, beginning at the one lowest, and going up the river.

Water-power of the Mersey River.

Milton Falls.—Situate in Milton, just above tide-water, $2\frac{1}{4}$ miles from Liverpool. Two good wharves within one mile of the mills. Total height of the fall at low tide 13 feet. Height of dam 7 to 8 feet. Total head developed, 8 to 10 feet, according to height of water in the river. Dam is the ordinary style of timber dam, built of cross sills and pointers.

Mills on these falls are as follows:—

(1), John Milliard's saw mill, two rotaries and one gang, with all the necessary machinery for doing general mill business. Handles lumber, laths, and box stuff of all kinds. Does a large business in dimension timber. Mill cuts from 30 to 35 thousand per day.

(2), Tupper's gang saw mill, purchased by Lewis Miller, of Ingram Port. This mill runs mostly on custom work. Cuts from 10 to 15 thousand per day.

(3), Power-house of the Milton Electric Power and Manufacturing Co., Ltd. Provides power for lighting the village of Milton, also for Claude Hartlen's wood-working factory and John Wolker's turning shop. 100 horse-power developed.

Total power developed on these falls, 400 to 500 horse-power. Can be greatly increased by the addition of more water wheels.

Potanoc Falls.—Situate in the village of Milton, distance from Liverpool $3\frac{1}{4}$ miles. The dam at Milton Falls backs water to the foot of this dam. Available head 8 to 10 feet. Height of dam 7 to 8 feet. Dam built of logs, cross sills and pointers. Mills on this dam are as follows:—

(1), Harlow & Kempton's gang and rotary saw mills. Fitted up with all the necessary machinery for doing a first-class saw mill business, capable of getting everything out of the log. Cuts lumber and dimension stuff of all kinds, as well as laths and box stuff.

(2), Harlow & Kempton's wood-working factory, manufacturing sashes and doors, boxes, mouldings, and house finish of all kinds.

(3), L. H. Minard gang saw and planing mill. Besides cutting his own stock this mill also does custom work.

(4), Ford Brothers' rotary mill. Lately purchased by Geo. P. MacLearn. This mill has been principally used in cutting hardwood, for which there is a good demand.

Total power developed on these falls about 450 horse-power. Capacity of mills about 50 thousand daily.

Cowie's Falls.—Situate immediately above the Potanoc Falls, about $3\frac{1}{2}$ miles from Liverpool. The dam at the Potanoc Falls backs water up to the foot of this dam. Height of dam 20 feet, built of logs. Available working head 20 to 22 feet.

Mill owned by Acadia Pulp and Paper Company, manufactures ground pulp. 1500 horse-power developed. Daily output of mill 22 to 25 tons.

Rapid Falls.—Distance from Liverpool $4\frac{3}{4}$ miles. Height of dam 10 feet, built of logs. Available working head, 32 feet. This power was developed by building a dam at the head of Rapid Falls and diverting the water by means of a canal excavated in the high ground, to a point about 1400 feet down stream, at which place the mill is situated. Total power developed, 2,827 horse-power.

This mill is owned by the Acadia Pulp and Paper Co., and manufactures ground pulp. Daily output, 50 to 60 tons. In both these pulp-mills more power could be developed for a large part of the year if additional wheels were installed.

Guzzle Falls.—Town of Liverpool electric power station. Distance from Liverpool about $5\frac{1}{2}$ miles. Height of dam 6 to 8 feet, built of logs. The dam at Rapid Falls backs water up to the tail-race of this plant.

This power was developed by placing a dam at the head of Guzzle Falls and diverting the water by means of a natural channel nearly one-half mile long, into a basin or reservoir with earth embankments from 2 to 18 feet in height. A timber flume, 350 feet in length, passes the water to the wheels. This plant is laid out for further development, the penstock is built for three sets of wheels, only one of which is yet installed. Head 20 feet. 750 horse-power developed. Power stations contain two 250 K. W. Bullock electric dynamos.

The above are all the water-powers so far developed. They occupy a total length along the river of $3\frac{1}{4}$ miles, and the total of all the different heads, together with an allowance made for some fall that is unavoidably lost to prevent the flowage of one dam interfering with the tail-water of the mill above it, will be in the vicinity of 100 feet. As before mentioned the Mersey river has a total fall in about 16 miles of 260 feet, so it will

be seen that there is still left undeveloped on this river a total fall of approximately 160 feet, extending over a length of river of about 13 miles. In this length of 13 miles there are at least three possible power sites, namely, Lower Great Brook Falls, Big Falls and Lake Falls. All of these are good powers, and the site at Big Falls is probably the largest water-power on the river. The falls have been named in their order going up the river, and the distances from Liverpool are respectively 8 miles, 12 miles and 18 miles.

Power at Present Developed.

A summary of the power developed on the Mersey river at the present time is given below:—

Milton Falls	400	horse-power.
Potanoc "	450	"
Cowie's "	1,500	"
Rapid "	2,827	"
Guzzle "	750	"

By these figures is meant that wheels to develop the power enumerated here have been installed, or, as in the case of the Liverpool plant that flumes, etc., of capacity large enough for that amount of power have been constructed. What I do not wish, however, to convey is the idea that these plants are developing the amount of power mentioned every day in the year, for they are doing that for probably only nine months on the average in each year, and the minimum power in the dry period is very likely only 25 per cent., or less, of the quantity mentioned. I want to show, however, that each of the power plants at present in operation is capable of much further development when advantage is taken of the immense natural storage that nature has so liberally provided. The question of storage is so intimately connected with the Mersey Hydraulic Company that I must first attempt a description of that company and its powers.

Mersey Hydraulic Company.

The Mersey Hydraulic Company is a company incorporated in the year 1902, and formed for the purpose of improving the water-powers on the Mersey river. It is given power in its act to acquire lands around the lakes, to build dams, etc., and to store water in the lakes on the Mersey river for the purpose of using it or selling it for power purposes, or for other uses. The company has, since incorporation, expended in the vicinity of $20,000 in acquiring flowage lands, building dams, etc., but for some reason unknown to the writer, the dams for flowage are in an incomplete state, and accordingly, it is unable at present to give anything like the increase of power that might be got. A small expenditure of not over $5,000 would suffice to do all the necessary work to enable it to store water over an extremely large area, and when I say that the completion of one dam will store water in three lakes aggregating 22 square miles in area and a depth of six feet, it will readily be seen what large increases of power may be got from storage. Besides, water can readily be stored in other lakes if it is wanted. The effort made so far by the Mersey Hydraulic Company to increase the power on the river from storage, has not been an unqualified success, and the writer cannot explain why this is so. I think, however, it must be admitted that the possibilities of improvement are there, and some change in the management or policy of the company may be arrived at that will benefit and give satisfaction to all the operators on the river. I have heard it advocated that the government should take control of the situation, but that, to my mind, would not be the solution of the difficulty. The great object, first of all, is to get more mills in operation, and when once you have more owners of factories looking for the maximum continuous power to operate their mills, then you will have a board of control that will either dictate to the Mersey Hydraulic Company or merge itself into

the company, or be able to make such strong representations that the government will enact such legislation as will enable the most to be got out of the water-powers. As for the control, I should say it should certainly be in the hands of the owners of the water-powers, both to assess the proportion of expense to be borne by each, and to direct the situation generally. One thing to me seems sure, advantage must be taken of the very large storage before the greatest benefit is obtained from the water-powers on this river. I have already stated that 5,927 horse-power is developed in the river, but for three-month dry period in each year this much is not obtained. Now were the full storage properly developed and distributed, not only could a larger amount of power be obtained every day in the year, but every mill owner would feel warranted in adding additional wheels for the sake of the power to be got for two-thirds of the year.

I would put the estimate of continuous power to be obtained on the Mersey river as follows:—

Powers at present developed. .	7,000	horse-power.
Undeveloped powers	8,000	"
Total.............	15,000	

The above is a very conservative estimate, and one I am perfectly sure can be obtained. In making the estimate I am supposing that the storage capacity is fully utilized, and the stored water distributed over the dry summer period. This is a very large amount for continuous power, and were it all fully utilized for manufacturing purposes, this part of the country would become one of the most prosperous and populous in the province. For many manufacturing purposes it is sometimes quite satisfactory if the mills can operate eight or nine months out of the year. This might be the case with saw-mills or even with ground-pulp mills, and if I were to estimate the amount of power that it was possible to develop on the river under that condition I would put it at not less than 40,000 horse-

power. Even at the figure 15,000 the power to be got is enormous, and with the aid of electricity it can be adapted to almost any and all purposes, both close at hand or at a considerable distance away.

The writer made a trip last summer down the Mersey river and was at that time very much impressed with the great possibilities for water-power development, and the more I have thought over it since the greater has been my wonder that it has not been taken advantage of. The Mersey has always been one of our best rivers for lumbering operations, and many millions of feet have annually been shipped away to all parts of the globe. Almost the whole of the lumber, however, has gone in a rough state, and is manufactured in other places; and this is just the point which I cannot reason out, for why should the real manufacture of this lumber be done in other places when the Mersey furnishes power at one-quarter the average cost in other places. It would seem to me that there are almost unlimited possibilities in the manufacture of wooden ware of all kinds. Besides all the articles in hard and soft wood required for the building trade, there are innumerable smaller articles that could be made, such as broom handles, tool handles, pegs and lasts, etc., in fact, no article so small as long as it uses up all the good parts of the wood, and there is no waste as there is when only rough lumber is shipped. There is plenty of room, and lots of the best hardwood for a good furniture factory. Hitherto, immense quantities of hemlock have been cut on this river, and as the logs are stripped of bark before they are rafted, the hemlock bark has been lost altogether, but with a tannery on the river, or even improved facilities for getting it out, another profitable industry could be started. I shall not enlarge on the pulp industry, for it seems to have been well demonstrated already, although perhaps, more mills might be added. I think, however, my remarks about the product of the saw mills might well be applied to the pulp mills also, that is, that the process of manu-

facture should be carried further and paper manufactured. The further the process of manufacture is carried forward the larger the number of men employed, and the more money left in the country for circulation. I should not presume to dictate to our lumber merchants, who I know full well are among our best business men, and yet it may be in certain of our industries we, as Nova Scotians, have got into a "rut." Our neighbors to the south are particularly quick to see a good business opening, and if the Nova Scotians are to keep up in the race they too must keep alive and take advantage of every possible opportunity. This, too, is an age of big things, to get the most out of them, our industries must be on a larger scale, and in the case of these water-powers the ideal state of things would be that one factory should either use the product of another on the river, or some part of the raw material not used by others, and every small particle of our raw material should be manufactured before it is shipped. If we consider the immense tracts of woodland around the Mersey, it can be satisfactorily demonstrated that the forest growth is practically inexhaustible if properly looked after and protected from fires, so that any industry located on the river for the manufacture of anything in the line of wood would be an established fixture. The further the process of manufacture is carried on the less the cut of logs is likely to be, for nothing could be so destructive to our forests as the way they have been depleted for the cutting of deal.

I have said nothing so far about industries connected with anything but lumber, as that seems the most natural use to put the power to, as well as the most profitable. There are, however, other uses for power if transmitted to the mines in the country, for Queens county is rich in minerals, and its gold mines are particularly valuable. In fact, electricity can be so cheaply developed on this river that it can be delivered by long transmission lines at comparatively small cost.

Facilities for Transport.

One of the greatest considerations with the manufacturer of any kind of goods is the proximity of his factory to his market, and the cost of getting his product transported. A manufacturer may be situated at quite a distance from where his goods are sold, and yet, if he has good communication and cheap rates of freight he may be better situated than if he were much nearer his market but had poorer transport facilities. Now I want to show that as regards the powers of the Mersey any manufacture can be readily marketed, and, in fact, I think the situation could hardly be improved, and that it only requires that the conditions become better known to have it promptly taken advantage of. As stated before, the towns of Liverpool and Milton are but 2½ miles apart. Liverpool is the shipping port, while the bulk of the manufacturing has always been done at Milton. There has always been a friendly rivalry between these two places, but to an outsider they are all the same, a people busy, industrious and enterprising to no common degree. That the people of these places have always had faith in their towns, and in their prospects, is evidenced by the uncommon number of neat and pretty residences, and a stranger to the place cannot but be impressed with the care and taste displayed in the arrangement of the grounds and the placing of beautiful shade trees. They have an air of prosperity not always worn by towns of their size. The town of Liverpool has an excellent harbour opening out into the Atlantic, and has exceptional advantages as a shipping port. In the town there is an up-to-date machine shop and foundry, and other factories. They have also a marine railway operated by electric power supplied by the town, and this is the only marine railway on the continent that is so operated. Ship-building is carried on extensively in the town, and the products of the ship-yards are in demand as being the staunchest and best models of wooden ships obtainable.

Milton occupies both sides of the river where it has been broadened out by dams, and is one of the busiest places to be found in the province. The buzz of machinery is heard all over the place, and everybody appears busy and contented. Soon after the starting of the pulp mills a steam tramway was built up the left bank of the river, connecting the mills with the different wharf properties in Liverpool, and has been used to ship the products of the mills, although pulp has been the staple freight outward and pulp-wood inward. I am of opinion that this tramway could be more economically and best operated by electricity, and I feel there will not be any great difficulty in extending this line up the river as far as Indian Gardens, and if this were done every water power on the river could be profitably utilized, for, with more patronage for the road, cheaper freight rates could be had, and with cheaper freight rates and plenty of freight to carry, both tramway and the manufacturer should make money. It does not seem that a factory situated anywhere on the Mersey would pay any more freight per ton for its product delivered on the wharf ready for shipment than many concerns not so favourably situated do for truckage. Now, the rates for water carriage are, as a rule, very much below the rates for rail carriage, and any concern so situated as to be able to ship by water has an immense advantage in marketing its product. As Liverpool harbour is open all the year round, no better shipping port could be desired, and manufactured products from any mill or factory situated in Liverpool or vicinity should be able to successfully meet in competition with those from any other place.

The town of Liverpool supplies electricity for power purposes at a very low rate as an encouragement to manufacturers. There is still room for industries requiring a moderate amount of power in the town, and there seems to be every advantage in the location, cheap power, cheap water and light, and low rate of taxation. Since starting this paper I have learned that construction is already started on a paper box and paper mill at

Milton. It would seem that the manufacture of these articles in the place would be an added inducement to other factories which use paper boxes to hold their product, to locate here, as they must get this part of their material at a cheap rate.

The counties of Queens and Shelburne were so long without railway communication that hitherto their natural advantages were not so widely known as they should have been, and there was perhaps some excuse for the undeveloped state of this part of the country. There have been, perhaps, a further excuse that there was no useful work for these great natural powers to do, but now that the old state of things is no more, and there is good and free communication by rail with all parts of the province, coupled with the fact that at present there is a decided activity in Canada in all industrial pursuits, the magnificent water-powers on this river should not lie idle any longer, and I think it is safe to predict that with a little judicious advertising to make the situation known, all the water now going to waste will be harnessed to some useful work, and the Mersey river, from its mouth to the Indian Gardens, will have a succession of large mills and factories along its banks, making all kinds of goods for shipment abroad, and disbursing enough in wages to sustain many times the present population.

Although the Mersey is undoubtedly the best water-power stream in the province, yet it must not be forgotten that there are many other excellent powers on other streams, and even in the same county of Queens there are several water-powers both developed and undeveloped. The Mersey powers, however, are exceptionally well sustained, both as regards getting the raw material to the factory, and the shipment of the manufactured product, and this fact would, I think, commend them to anyone looking into the situation. I may say that I hold no "brief" to speak for anyone or for any interest on the river. I have, however, had it impressed upon me as the result of a few weeks

spent in this vicinity, that the powers on this river are likely to become important factors in our commercial life, and a source of wealth and profit to the owners as well as to our native province.

I think that we as Nova Scotians are beginning to realize that our province is rich in its resources, and I am firmly convinced that we as yet have only begun to find out how very rich they are. We hear much of the boundless possibilities of western Canada, and are, perhaps, too apt to give too little attention to the development of the eastern portion, but there is no doubt that if we would only emulate the push and energy displayed in opening up the west, and at the same time take full advantage of all the great natural advantages at our disposal, this fair province could be made as prosperous and populous a country as any part of the British dominion.

In preparing this short paper I have been forced to put several friends under tribute for information needed. I am indebted to the provincial engineer, Mr. MacColl, and to the Hon. Justice Forbes, for much help, but I am especially indebted to Mr. John S. Hughes, pulp manufacturer of Milton, for much detail information that could only be acquired by one who had a long and intimate acquaintance with conditions on the river.

WATER-ROLLED WEED-BALLS, SEA-BALLS, BURR-BALLS, OR VEGETABLE-BALLS, Collected near Upper Kinsgburg, Lunenburg County, Nova Scotia.

(To illustrate paper by Dr. MacKay.)

(Face p. 667)

Water-Rolled Weed-Balls.—By A. H. MacKay, LL. D., F. R. S. C., Halifax.

(Read 21st May, 1906.)

In February, 1906, I received a letter and a "sea-ball" from the teacher at Upper Kingsburg, Lunenburg county, a school section in the north-eastern angle formed by the river LaHave and the coast. The pupils were described as "fairly burdened with curiosity" about the strange things cast up by the sea on this sandy beach on the Atlantic. The west bank of the great LaHave, running at right angles into the ocean until it reaches Gaff Point, where it is submerged to rise further out in the far-famed Ironbound Island, protects this bit of shore from the full force of the south-westers.

The teacher, Miss Mary L. H. Bowers, describes the natural history of this beach in terms of the folk-lore of the coast as follows:—

"For years back, the weeds cast upon these shores were of the larger kinds, such as Rockweed, Irish Moss, and Kelp or Laminaria. Sea urchins were the pest of the lobster fishing. About three years ago the sea cast up such immense numbers that the whole coast was abundantly supplied with fertilizers for the farms. This wholesale destruction of animal and vegetable life was looked upon as something which could not be explained. Since then, however, the lobster fisherman believes that the sea bottom shows fewer clean spots of sand, and a great increase of the finer thread-branched sea-weeds. Last year great quantities of red sea-weeds have been thrown ashore; and now, this winter, these 'sea-balls,' as they are called, are being cast up, and the people declare it to be a new thing. Some take them to be the nests of shell fish. In proof, as many as 400 minute shells, taken to be the young of clams, have been counted out of the centre of one of these balls. But then the most of them have few or no shells within them. I have seen perhaps two hundred balls on a short strip of beach, of various sizes, and in different stages of perfection, specimens of which I am sending you."

These "sea-balls" are photogravured on the accompanying plate, with a scale which allows them to be exactly measured.

The last one in the third horizontal row is cut in two, but shows nothing in the centre different from the rest of the ball.

These specimens varied from spheres about five inches in diameter to one and a half inches. Some were elongated. The one on the right, in the upper row, has a frond of *Laminaria digitata* Lamx. passing through the centre of the ball in its longest direction, and has in addition at its opposite polar extremities, *Dictyosiphon fœniculaceus* Grev. growing on a fragment of a waterworn clam shell, and other similar filamentous branching algæ, not worn off, as they are in the compact equatorial region. A little more rolling in water over the sand, or by the wind over the dry beach, would likely soon wear off the appendages down to a compact spheroid.

Some of the balls contain the roots of one of the larger seaweeds within them, one a mass of *Corallina officinalis* L. Others contain embedded in them, various red sea-weeds, and even masses of marine sponges. But they appear to be built up mostly of the filamentous and fine branching olive brown algæ, such as *Dictyosiphon*, *Desmarestia*, *Ectocarpus*, *Chordaria* and *Chorda*, with specimens of nearly every other local species of seaweed, including material to which they were attached when growing, or with which they might become entangled when massing into balls.

Their structure in the different forms examined suggest their formation from light ridges of algæ left by the retreating tide on the flat sandy shallows. Under the sun the weeds curl and lock into masses which, when moved over the sand by alternate tides and winds, occasionally produce very round balls. It would appear that the filamentous and fine branching olive-brown algæ are more brittle than many of the red species which are often found like the larger olive algæ, extending beyond the general contour of the rolling ball.

Mr. Harry Piers, curator of the Provincial Museum, has received a similar ball, collected by Mr. J. Perrin, from the

sandy beach on MacNab's Island at the mouth of Halifax Harbor, where others were noted, and also a specimen from a fresh-water lake near New Ross, Lunenburg county.

Mr. P. B. Lantz, of New Ross, Lunenburg county, has found them in a fresh-water lake near the head of Gold River, and in Indian Lake in New Germany. The people think they are nests made by the water newts found in these lakes—probably the aquatic stage of *Diemyctylus viridescens* Rafinesque—just because these two objects are the two mysterious things found together in the same place. The fresh-water balls are spoken of as the nests of the newts or as burr-balls, the former suggested by the proofless, popular hypothesis referred to, the latter by their appearance.

Professor W. F. Ganong read, 3rd May, 1904, a paper "On Vegetable-, or Burr-, Balls from Little Kedron Lake, N. B.," which is published on page 304, vol. v., part iii., no. xxiii., of the *Bulletin of the Natural History Society of New Brunswick* with a photogravure of two balls, one from Lake Kedron and the other from Sandy Pond in Lincoln, Massachusetts. The former was found in a sandy cove of the lake, open to no wind except from the south-east. The cove is surrounded with fir and spruce, whose leaves fall into the water. The balls are composed chiefly of these leaves, including other vegetable matter, such as small twigs, etc., all interlocked together. The latter, from Flint's or Sandy Pond, was composed mainly of the tangled stems and leaves of the Duck grass *(Eriocaulon septangulare)* which was growing in the lake. Thoreau, in chapter ix of his *Walden,* describes this phenomenon in the identical lake in the following words:

"I used to admire the ripple marks on the sandy bottom at the north end of this pond, made firm and hard to the feet of the wader by the pressure of the water, and the rushes which grew in Indian file, in waving lines, corresponding to these marks, rank behind rank, as if the waves had planted them. There also I have found, in considerable quantities, curious balls, composed apparently of fine grass or roots, of pipewort, perhaps, from half an inch to four inches in diameter, and perfectly spherical.

These wash back and forth in shallow water on a sandy bottom, and are sometimes cast on the shore. They are either solid grass, or have a little sand in the middle. At first you would say that they were formed by the action of the waves, like a pebble; yet the smallest are made of equally coarse materials, half an inch long, and they are produced only at one season of the year. Moreover, the waves, I suspect, do not so much construct as wear down a material which has already acquired consistency. They preserve their form when dry for an indefinite period."

Professor Ganong wrote, August 1904, in the *Educational Review* of Saint John, New Brunswick; and 8th April, 1904, in *Science* of New York; asking for references to similar observations; but he obtained at that time only one additional reference to a locality—" a lake in Idaho."

The observations of Miss Bowers on the Atlantic coast near the mouth of the LaHave, and the specimen reported from MacNab's Island, extend our knowledge of the formation to marine waters—even to oceanic beaches. The spheroidal, and even cylindrical, masses point clearly to the action of the water as the main cause. The deposition of a mass of eggs on a roll of such algæ would be one condition to agglutinate into a nucleus a mass which might later contain young marine life within the centre of the future ball. Roots of algæ and other entangling forms are often conspicuous as nuclei. But often the whole mass appears to be composed of the more attenuated olive-brown algæ. Although an addition has been made to our knowledge, there are still wanting more definite demonstrations of the exact manner in which these ball forms are originated as well as rounded. The phenomenon must also be occurring more widely than hitherto observed. What has been observed so far suggests as an appropriate title for them: " Water-rolled Weed balls."

THE attention of members of the Institute is directed to the following recommendations of the British Association Committee on Zoological Bibliography and Publications :—

"That authors' separate copies should not be distributed privately before the paper has been published in the regular manner.

"That it is desirable to express the subject of one's paper in its title, while keeping the title as concise as possible.

"That new species should be properly diagnosed and figured when possible.

"That new names should not be proposed in irrelevant footnotes, or anonymous paragraphs.

"That references to previous publications should be made fully and correctly, if possible in accordance with one of the recognized sets of rules of quotations, such as that recently adopted by the French Zoological Society"

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1902-1903.

Annual Business Meeting.

Legislative Council Chamber, Halifax, 24th November, 1902.

The President, Dr. A. H. MacKay, in the chair.

Presidential Address.—By A. H. MacKay. LL. D., &c.

Gentlemen,—During the past year our Institute has been fortunate in losing none of its members. Our membership and funds have increased. The scientific work done by our members and affiliations appears to be extending, so that we have reason to expect more in the future than has been done in the past.

THE INSTITUTE'S WORK.

The work of last year commenced on the 7th of November, by a lecture on Roman Coins, by Mr. R. W. McLachlan, of the Numismatic and Antiquarian Society of Montreal, and an exhibition of the Roman Coins of our own Provincial Museum, by Mr. A. H. C. Prichard, of Brooklyn, New York, who studied and arranged the collection.

On the 9th of December, Professor Earnest Haycock, President of the Wolfville branch of the Institute, presented his report on the organization and work of the Wolfville Institute; and the members had the pleasure of studying an interesting variety of *Botrychium ternatum*, Swartz, (The Ternate Grape-Fern), collected at Blomidon, by Mrs. R. R. McLeod, of Brookfield, Queens County.

On the 13th of January, Dr. R. W. Ellis, of the Geological Survey of Canada, presented a valuable paper on the Progress of Geological Investigation in Nova Scotia; and we had the pleasure of inspecting a mounted collection of flowering plants, brought from Labrador in the months of July and August preceding, by Mr. Walter H. Prest.

On the 10th of February, Dr. H. M. Ami's paper on the Cambrian Age of the Dictyonema Slates of New Canaan and Kentville, opened up an interesting discussion in which Mr. H. S. Poole took a leading and most interesting part. Mr. Poole also exhibited a specimen of slate from near Green Bank, Point Pleasant, Halifax, showing curious markings like worm-trails.

Miss A. Louise Jagger, of California, prepared a provisional list of the flowering plants observed in Digby County, which was presented to the meeting. And Mr. T. C. Hebb, M. A., of Dalhousie College, presented a valuable paper on the Determination of the Freezing-point Depression Constant for Electrolytes.

On the 10th of March, Mr. Walter H. Prest read a supplementary paper on Drift Ice as an Eroding Agent, exhibiting specimens of sand and pebbles carried on ice along the Labrador coast. Professor Davidson, of the University of New Brunswick, prepared an important and elaborate paper on Agricultural Credit, which was presented to this meeting. R. S. Boehner, B. Sc., of Dalhousie College, also presented a paper on the Standardization of Hydrochloric Acid with Borax; and T. C. Hebb, M. A., of Dalhousie, presented a second paper, this time on the Determination of the Freezing-point Depression of Dilute Solutions of Electrolytes.

Owing to the impossibility of the completion of the remaining papers for presentation at the regular meetings subsequent, the Council authorized their publication in the forthcoming volume with those read before the Institute. These include the Phenological Observations made in the Public Schools of the Province, and by members of the Botanical Club of Canada; which were summed up under the direction of your president, and contain interesting obervations by Mr. C. B. Robinson, B. A., of the Pictou Academy, on the Early Intervale Flora of the North of Nova Scotia.

WORK OF AFFILIATED ORGANIZATIONS.

At the Wolfville local branch society, the attention of its members was engaged by Professor F. R. Haley, on Wireless Telegraphy; by Mr. V. L. Q. Chittick, describing the Government drill and its work at Hantsport, illustrated by specimens of cores produced by the machine. Rev. F. G. Harrington exhibited Land and Water Shells from the Loo Choo Islands. Professor Haycock gave an outline of the Geological Structure of King's County. Professor F. C. Sears demonstrated the Habits of Mud Wasps, with examples. Professor Ernest W. Sawyer discussed the Habitat and Habits of certain land and water Mollusca of King's County, illustrated by a collection of some fifty varieties and species. Professor Haycock sketched the manner in which veins of Minerals are formed. Dr. E. N. Payzant made remarks on Concentrates from Home and Foreign Mines, illustrated by specimens. And Mr. A. H. Ruggles discussed the Parasites of the Cabbage Worm, with illustrations. This course in itself was a valuable one, even when considered from a Provincial point of view.

The Halifax Botanical Club, under the presidency of Principal W. H. Waddell, of Halifax, met fortnightly during the winter months, in the reading room of the Provincial Science Library. The marine algæ was the principal object of study, and Rev. Clarence MacKinnon and other members made valuable additions to the local lists. During the summer following, the Club met weekly in the City Hall, for the study of the local flowering plants. Towards the end of the season some progress was made in the special study of the local Solidagos and Asters, in which some of the members became specially interested, on account of the variability of the species. Some interest was also developed in the violets, of which there appear to be more forms than was hitherto suspected.

GENERAL PROVINCIAL WORK.

These institutions are more or less affiliated with the Institute. But as the leading scientific organization of the province, it is appropriate that we should take note of other work being done in the same field. During the last two years the Marine Biological Laboratory of Canada was stationed at Canso; and under the directorship of Professor R. Ramsay Wright, Dean of the Science Faculty of the

University of Toronto, the biological characters of that region, and especially of the marine waters of the neighborhood were being studied. It is to be regretted that there were so few biologists of our own province who were prepared to work at the station during these years —two only having put in some time at the station. Next year it is possible the station may be somewhere on the Northumberland Straits; but whether it be on the Nova Scotian or the Prince Edward Island side, it will be as accessible as it was during the past two years. The work of the station has been hampered by the lack of sufficient grant from the Dominion Government; but it is hoped that this defect will be remedied during the present winter.

Another advance in the facilities of scientific instruction which should be noted, is the Summer or Vacation School, which was opened for the first time in the new and well equipped science building of the Provincial Normal School, which functions also as the School of Agriculture in affiliation with the buildings, appliances and stock of the Provincial Farm at Truro. About sixty students took advantage of the five weeks of chemical, biological and agricultural courses given there in July and August.

When we find that the Summer School of Science for the Atlantic Provinces of Canada, which met on this occasion at St. Stephen, New Brunswick, was also very largely attended, and that our Colleges (Dalhousie with its new Mining School, especially), as well as high schools are enlarging their facilities for giving good scientific instruction; and that there is a general sentiment abroad that we should lay more stress upon the development of the power to discover truth aud apply it in useful action, than on the power of imagining and its expression;—when we see these signs we have reason to believe that we are going to make more progress

RECOMMENDATION.

To return to our Institute again, I beg to suggest, that we may be more useful if we make our monthly meetings more popular. The popular presentation of subjects might be more simple and elementary; and their function would be the inspiration of young members to commence a course of special investigation. Such presentations would not be published in our Transactions, of conrse; for the

publication department is for new knowledge. On the other hand, much of the new knowledge gathered up will be interesting only to those engaged in these departments ; so that the abstruse but valuable paper might be read merely by title, to be published for the careful reading of workers interested in these subjects throughout the world. Hitherto our audience has been world-wide, but not local. It may be more valuable, perhaps, to introduce the public into our local audiences for the purpose of stimulating a more rapid increase of local recruits, when we can soarrange it as not to interfere with the wider audiences, and the recording and publication of the new facts discovered in the survey of our own small corner of the universe.

IMPROVING FACILITIES.

I have to note the great advantages which the Provincial Government has conferred on the scientific public and on all the industries dependent on scientific knowledge and skill, by the equipment of the Provincial Science Library and its continued aid. The library has been increasing rapidly from the exchanges of the Institute with all the leading scientific societies of the world, from the co-operation of the Mining Society, and from the direct addition of the most essential books bearing on our provincial industries by the Government.

Under the indefatigable and intelligent direction of the librarian the library will soon be completely and most effectively catalogued. The undetermined material in the Provincial Museum has also been to a great extent examined, classified and labelled by the same individual, Mr. Harry Piers, who to the duties of librarian and secretary of our Institute adds that of the curator of the Museum. But not content with the curatorship alone, he is constantly making arrangements for the increase of the collections with a view of illustrating the natural history and industrial potentialities of the province as completely as possible. This work must go on for ever, of course ; but the advance made during the past year is very creditable to the energy and tact of our secretary.

There are many signs of increasing interest in the exploration of the natural history and resources of the province, not only in the usual quarters, but in connection with our public schools, which have already made contributions to science in connection with their elementary local

observations. And their initiative has been followed already in some portions of Canada and in Europe. Some of our high school teachers, and even of our common school teachers, are now doing very valuable local observation work; and if the spirit continues not only shall we be able to publish more original research in the future, but we will be able to develope our resources more effectively.

THE CHECKING OF MALARIA.

I attempted to illustrate the value of original research work such as we are endeavoring to stimulate here under our local conditions, by reference in my address of 1900 to the cumulation of the long series of scattered and unproductive work in the discovery of the true natural history of malaria, and in my address of 1901, to the still further utilitarian result of determining the probable nature and general manner of the communication of yellow fever. I am glad to be able to say that knowledge has proved in these cases to be power to do what millions of money and all of the beliefs of the world for the past ages were unable to effect. The manner in which human life was tortured and destroyed, in which business and commerce were upset, and in which valuable property was wasted by quarantine and other regulations based on a defective if not false theory of the natural facts, forms in the light of present developments an overwhelming testimonial to the ultimate value of the results of the long search after the truth and truth only.

In some of the leading malarial centres the sanitary regulations based on the new knowledge have promptly reduced this disease to a fraction of its former prevalence. And although the control of the mosquito nuisance is an admittedly tremendous contract, we can confidently expect from the success already attained the future extermination of malaria as one of the human ills.

THE EXTINCTION OF YELLOW FEVER.

Yellow fever may be considered to be already mastered, so completely have the experiments to which I last year alluded given the power of control to man.

Taking Havana, where for 130 years yellow fever has been constantly in the city, and near which the final experiments alluded to

were made, we find a most interesting illustration of my general argument. When the United States Government took charge of the city it was thoroughly cleaned and began to be supplied with the best modern sanitary appliances. But while these improvements advanced the general health of the city, yellow fever was not diminished at all. On the contrary it was argued that it had been increased. In 1899 there were 103 deaths from it, notwithstanding more than a year's application of the most stringent modern sanitary regulations. And in 1900 the death roll went over 300. The additional cleanliness of the city had no beneficial effect, for the patients became more numerous, especially among the well-to-do classes, who enjoyed all the advantages of science up to that date. In fact, this year one-half of the members of the Governor-General's staff were carried off by the disease.

How are affairs now since the theory that the fever is always distributed by the particular mosquito called *Stegomazia fasciata*, has been applied? Within two hours after a case is reported the patient is covered with a mosquito netting. The room and house is thoroughly fumigated so as to kill all mosquitos present. Adjacent houses are also fumigated. All open water in pools, cisterns or vessels that might act as breeding places for the larvae, are emptied, cleaned and carefully covered. Still water of any kind in or near the city is drained off or covered with a film of petroleum. No precautions are taken to keep the well from the sick. Mosquitoes alone are the only prohibited parties.

These measures were instituted towards the end of February, 1901. In January there had been seven deaths from the fever. In February there were five deaths. In March there were but one. None were reported in May and June. There was one in July and another case in September. Since then, for over a year, up until this present month, there has not been a single death from yellow fever in Havana, the native nest of the disease for 130 years. One of the most terrible scourges of humanity in the tropical regions of America has been captured, and can now be handed bound into perpetual imprisonment;—all through the study of the plodding devotees of science, who for years have been seeking for the truth of the little things about them, without which the present productive development could never have materialized, any more than there can be a harvest without the seed-time of spring.

Thanking the Institute for the high honor of my election to the presidency for the last three years, and regretting that I was not better able to fulfil the duties of so important a post, I now ask you to proceed with the regular work of our annual meeting.

The TREASURER'S report was presented, and having been audited and found correct, were received and adopted. The following is an analytical statement of the expenditure for 1901-1902 :

PUBLICATION OF TRANSACTIONS :—		
Vol. X , Part 3, (1900-1901) :		
Engravings and expressage on same	$ 20 85	
Vol. X., Part 4, (1901-1902) :		
Engravings	1 04	
		$ 21 89
DISTRIBUTION OF TRANSACTIONS :—		
Vol. X , Part 3 :		
Addressing and supervising distribution		15 00
LIBRARY EXPENSES :—		
Self-inking stamps	$ 4 00	
Expressage on books	1 70	
		5 70
Calling meetings		10 32
Chairs for meetings		2 50
Advertising Annual Meeting		9 50
Postage (Secretary's)		78
Telegram		35
Letter file		65
Typewriting report to Royal Society		50
Truckage on black-board		50
		$ 67 69

The Report on the Library was presented by H. PIERS, and was received and adopted.

A report from PRESIDENT E. HAYCOCK, of the KING'S COUNTY BRANCH OF THE INSTITUTE, Wolfville, N. S., on the work done by the branch during its second session (1901-1902) was read by MR. PIERS.

Papers Presented to the King's County Branch of the N. S. Institute of Science (Session of 1901-1902.)

13th January, 1902.

1. Wireless Telegraphy ; illustrated by black-board diagrams.—By Professor F. R. Haley, Acadia College.
2. Description of Government Drill and its work at Hantsport, N. S.; illustrated by specimens of core produced by the machine.—By V. L. O. Chittick.

10th February, 1902.

3. Exhibition of Land and Water Shells from Loo Choo Islands.—By Rev. F. G. Harrington.
4. Outline of Geological Structure of King's County, N. S. ; illustrated by black-board diagrams.—By Professor Ernest Haycock, Acadia College.

17th March, 1902.

5. Habits of the Mud Wasp ; illustrated by specimens.—By Prof. F. C. Sears, N. S. School of Horticulture.
6. Habitat and Habits of certain Land and Water Mollusca of King's County, N. S. ; illustrated by a collection of some fifty species.—By Professor Everett W. Sawyer, Acadia College.
7. Wireless Telegraphy ; illustrated by working apparatus.—By Prof. F. R. Haley, Acadia College.

22nd April, 1902.

8. Notes on Land and Fresh Water Mollusca of King's County, N. S. ; illustrated with specimens.—By Prof. Everett W. Sawyer.
9. Sketch of Manner in which Veins of Minerals are formed ; illustrated by black-board diagrams.—By Professor E. Haycock.
10. Remarks on Concentrates from Home and Foreign Mines ; illustrated by specimens.—By E. N. Payzant, M. D.
11. Parasites of the Cabbage Worm ; with black-board diagrams.—By A. H. Ruggles, San Jose Scale Inspector.

The attendance at these meetings averaged about twenty-five. In addition to those who became members of the parent institution through the branch society, a number became associate members of the local branch, paying a fee of twenty-five cents.

The report was received and adopted.

The RECORDING SECRETARY laid on the table the Proceedings and Transactions of the Institute, Vol. X., Part 3, which had recently been published.

It was resolved that the thanks of the Institute be conveyed to the HON. SIR ROBERT BOAK and HIS WORSHIP THE MAYOR for their courtesy in granting the society the use of the Legislative and City Council Chambers as places of meeting, and to the SECRETARY OF THE SMITHSONIAN INSTITUTION for continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

The following were elected officers for the ensuing year (1902-1903):

President.—HENRY SKEFFINGTON POOLE, A. R. S. M., F. G. S., F. R. S. C., *ex-officio* F. R. M. S.

Vice-Presidents.—F. W. W. DOANE, C. E., and PROF. EBENEZER MACKAY, PH. D.

Treasurer.—W. C. SILVER.

Corresponding Secretary.—A. H. MACKAY, LL. D., F. R. S. C.

Recording Secretary.—HARRY PIERS.

Librarian.—HARRY PIERS.

Councillors without Office.—MAYNARD BOWMAN, B. A., WATSON L. BISHOP, MARTIN MURPHY, D. SC., WILLIAM MCKERRON, PROF. STEPHEN M. DIXON, B. A., B. A. I., EDWIN GILPIN, JR., LL. D., F. R. S. C., ALEXANDER MCKAY.

Auditors.—RODERICK MCCOLL, C. E., J. B. MCCARTHY, M. A., B. SC.

A vote of thanks was presented to the retiring President, DR. MACKAY, for the energy and zeal with which he had discharged the duties of president during his term of office, and also for this excellent presidential address.

FIRST ORDINARY MEETING.

Legislative Council Chamber, Halifax, 8th December, 1902.

THE PRESIDENT, H. S. POOLE, in the chair.

It was announced that the following had been elected corresponding members: GEORGE U. HAY, D. Sc., F. R. S. C., St. John, N. B.; JOHN MCSWAIN, Charlottetown, P. E. I.; PHILIP COX, B. Sc., Ph. D., Chatham, N. B.; and E. R. FARIBAULT, B. A., B. Sc., Geological Survey of Canada, Ottawa; that PROF. J. EDMUND WOODMAN, M. A., D. Sc., Dalhousie School of Mining and Metallurgy, Halifax, had been elected an ordinary member; and that C. B. ROBINSON, B. A., Pictou, N. S., had been elected an associate member.

A paper by R. R. GATES, of Mount Allison University, entitled, "Middleton Fungi, with general remarks," was read by DR. A. H. MACKAY. (See Transactions, p. 115. The list of species is incorporated in Dr. MacKay's list of the Fungi of Nova Scotia, Transactions, p. 122).

A. H. MACKAY, LL. D., F. R. S. C., presented a paper on "Fungi of Nova Scotia," illustrating his remarks with dried specimens and microscopic preparations, as well as blackboard drawings. (See Transactions, p. 122).

SECOND ORDINARY MEETING.

Legislative Council Chamber, Halifax, 19th January, 1903.

The PRESIDENT, H. S. POOLE, in the chair.

On motion of Dr. A. H. MACKAY and W. MCKERRON, it was resolved that officers of the garrison in Halifax, who intimate a desire to attend meetings of the Institute, be eligible for corresponding membership, while resident in the province.

MAJOR ENGLISH, R. A., delivered a lecture on "Guns and Gunnery, illustrated by models and diagrams."

The subject was discussed by the PRESIDENT, COL. F. H. OXLEY, 1st C. A., and COL. J. R. MACSHANE.

A vote of thanks was presented to MAJOR ENGLISH for his highly instructive lecture.

THIRD ORDINARY MEETING.

Legislative Council Chamber, Halifax, 9th February, 1903.

The PRESIDENT, H. S. POOLE, in the chair.

It was announced that the following had been elected ordinary members: PARKER R. COLPITT, city electrician, Halifax; RICHARD H. BROWN, M. E., Halifax; and that R. R. GATES, Mt. Allison University, Sackville, N. B., had been elected an associate member.

PROF. E. E. PRINCE, Commissioner and General Inspector of Fisheries, Ottawa, presented a paper entitled "The Swim Bladder of Fishes, a degenerate gland."*

PROF. PRINCE also delivered a lecture on the "Colours of Animals, their nature and meaning," illustrated with lantern-slides.

The subject was discussed by the PRESIDENT, DR. A. H. MACKAY, CHARLES ARCHIBALD, and ARTHUR P. SILVER; and a vote of thanks was presented to the lecturer.

The following paper was read by title:—"The Meso-Carboniferous Age of the Union and Riversdale Formations of Nova Scotia, and of their equivalents the Mispec and Lancaster Formations in New Brunswick," by HENRY M. AMI, D. Sc., of the Geological Survey of Canada.

FOURTH ORDINARY MEETING.

Provincial Science Library, Halifax, 9th March, 903.

The PRESIDENT, H. S. POOLE, in the chair.

A communication was read from the Royal Society of Canada, requesting the Institute to appoint a delegate to attend the former society's meeting in May next. The matter was referred to the Council.

Attention was drawn to the recent death of the Institute's treasurer, WILLIAM CHAMBERLAIN SILVER, and a resolution of regret was unanimously adopted.

A resolution of regret was also passed on the death of A. CAMERON, principal of Yarmouth Academy, Yarmouth, an associate member of the Institute.

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* This paper will appear in part 2 of this volume.

A paper entitled "The Mira Grant," by EDWIN GILPIN, JR., LL. D., F. R. S. C., Inspector of Mines, was read by title. (See Transactions, p. 89).

DR. E. MACKAY took the chair, while the PRESIDENT read a paper by HENRY M. AMI, D. SC., F. R. S. C., of the Geological Survey of Canada, entitled, "The Meso-Carboniferous Age of the Union and Riversdale Formations of Nova Scotia, and of their equivalents, the Mispec and Lancaster Formations in New Brunswick."

A paper entitled "Note on *Dictyonema websteri*," was read by the PRESIDENT, H. S. POOLE, F. R. S. C.

These papers were discussed by DRS. A. H. MACKAY and MURPHY, and H. PIERS.

HARRY PIERS, curator of the Provincial Museum, exhibited and described three abnomal zoological specimens recently received at the Museum :—

(1) A moose skull *(Alce alces)* from Sheet Harbour, N. S., with unique cancerous development of the antlers.

(2) A melanistic specimen of the Garter Snake *(Eutœnia sirtalis)* from Yarmouth, N. S.

(3) An Abnomal Hare, taken at Stewiacke, N. S.

The subjects were discussed by DR. M. CHISHOLM, T. VARDY HILL, and others.

FIFTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 16th April, 1903.

The PRESIDENT, H. S. POOLE, in the chair.

It was announced that H. S. LAWRENCE, D. D. S., Wolfville, N. S., had been elected an associate member ; and JOHN J. JENNEY, Halifax, an ordinary member.

It was announced that the Council had elected WILLIAM MCKERRON, Halifax, treasurer of the Institute, to succeed the late W. C. Silver.

A communication by C. B. ROBINSON, B. A., of Pictou Academy, entitled, "Note on a Lichen-mimicing Caterpillar," was read by H. PIERS, as follows :—

"While walking through the woods near Pictou one afternoon, about the end of May or perhaps early in June, 1897, in company with W. A. Hickman, I saw upon his coat what seemed to be a piece of lichen. Picking it off with my fingers, I was surprised to find that it was a lichen-mimicing caterpillar. Mr. Hickman expressed a desire to keep it, and I took for granted that he would preserve it, and probably call attention to its existence. He, however, subsequently lost the specimen. In class one day at Cambridge, Prof. Newton showed us specimens from Madagascar, which to my recollection were almost identical with our form. The very fact that they are mimics would make it exceedingly doubtful, however, that there was any real affinity of species. In the intervening years I have searched again, especially at the season indicated, but totally without success."

PROF. J. E. WOODMAN, D. SC., Dalhousie School of Mining and Metallurgy, gave a lecture on "Yellowstone National Park," illustrated by lantern slides.

A vote of thanks was presented to the lecturer.

SIXTH ORDINARY MEETING.

Legislative Council Chamber, Halifax, 18th May, 1903.

VICE-PRESIDENT DOANE in the chair.

It was announced that W. F. JENNISON, of the Dominion Iron and Steel Co., Sydney, had been elected an associate member.

The following papers were read by title :—

(1). Is there Coal beneath Prince Edward Island?—By HENRY S. POOLE, F. G. S., F. R. S. C. (See Transactions, p. 1).

(2). Geology of Moose River Gold District, Halifax County, N. S.—By PROF. J. E. WOODMAN, D. SC., Dalhousie School of Mining and Metallurgy. (See Transactions, p. 18).

(3). Sections and Analyses of Nova Scotian Coals.—By EDWIN GILPIN, JR., LL. D., F. R. S. C., Inspector of Mines. (See Transactions, p. 8).

(4). Phenological Observations, Canada, for 1902.—By A. H. MacKay, Ll. D., F. R. S. C., Superintendent of Education. (See Transactions, p. 144).

(5). Botanical Notes.—By A. H. MacKay, Ll. D.

(6). Distribution of *Fucus serratus* in Nova Scotia.—By C. B. Robinson, B. A., Pictou Academy.

C. I. Pittman described some "eskers" which he had observed in the south western part of the province. Dr. A. H. MacKay described similar formations that had come under his notice, and showed how they were probably formed by ice agency. J. H. Townsend thought there was a ridge of a similar character in the vicinity of Salmon River, near Minesville, Lawrencetown, Halifax Co. N. S.

Parker R. Colpitt, city electrician, read a paper on "Wireless Telegraphy," illustrated by apparatus in operation.

The subject was discussed by the Chairman, and Dr. A. H. MacKay, S. A. Morton, A. M. Hoare, J. Burgoyne, W. McKerron, and J. H. Townsend; and a vote of thanks was presented to the lecturer.

The Council was authorized to receive as read by title, such papers as may be presented too late for this meeting.

HARRY PIERS,
Recording Secretary.

ERRATA.

Page 18, last line of foot-note, reference to Am. Geologist should read "vols. xxxiii and xxxiv."

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1903-1904.

Annual Business Meeting.

Legislative Council Chamber, Halifax, 16th November, 1903.

The President, Dr. Henry S. Poole, in the chair.

Presidential Address: (1) Progress of the Institute, (2) The Application of Science to Mining.

By Henry S. Poole, D. Sc., Assoc. Roy. Sc. Mines, F. G. S., F. R. S. C, Hon. M. I. M. E., &c.

Members of the Institute of Science: Gentlemen,—A year ago, when I was able to look back on a membership of thirty years, you honored me by election to the chair of this Institute. Now, as your President, it becomes a duty to submit a report of our proeeedings during the past year, and to bid you welcome to-night to this, the opening meeting of another session.

The reports of the various departments, which will be presented to you by our indefatigable secretary, and our painstaking treasurer will show our standing as a society, and the gains and losses we have sustained in membership. Of the former we are hopeful of usefulness to come, but of the latter we are in no uncertain doubt, as the Institute has suffered the loss of two important members, Mr. W. C. Silver, full of years and honors, and Mr. A Cameron, in the prime of life.

Mr. William Chamberlain Silver, who was born here of English parents in 1814, was for over half a century a well-known figure at

public meetings on various subjects, where his fine presence and pleasing address always commanded attention. Almost from the inception of this Institute, he took an active interest in its welfare, and until the day of his death continued to fill the important office of Treasurer.

In the loss of Mr. A. Cameron, the Institute is deprived of a contributor of exceptional ability on astronomical subjects, and provincial education, an acknowledged leader of the sort his country, Scotland, is so proud, and which has so often made a mark in the outer world.

THE INSTITUTE'S WORK.

During the late session, in addition to papers of the usual class that are read before us, we had meetings where the subject matter was, to a large extent, popularized by illustrations, models and diagrams that appealed to the eye.

Major English, R. G. A., who ranks among those of the service who have made a special study of guns and gunnery, explained very clearly, by blackboard and model, the advances in this direction that have of late made such strides. At the same time he showed how several branches of pure science, mathematics, chemistry, and metallurgy have been applied to practical account, and with a precision of result that is surprising to a civilian. Interest in his subject was excited at the time by press criticisms on the relative merits of the guns employed during the late Boer War.

Dr. A. H. MacKay, our President for many years, by ready free-hand drawing on the blackboard, and by specimens, described typical members of our native Fungi, while reading a paper on the subject from Mr. R. R. Gates, of Mt. Allison University, a promising student of this class of plants. He, at the same time, presented a summary of the species already identified as Nova Scotian. He also submitted a series of Phenological Observa ions conducted in 1902, in continuation of those of several previous years. The full series, now covering many years, should shortly enable deductions to be drawn of local variations of climate that will prove of much value.

Dr. Woodman, Professor of Geology at Dalhousie College, and who has lately brought among us the advanced views of Harvard University, entertained us and our friends by exhibiting slides of geological structure in the Rocky Mountains.

Mr. P. R. Colpitt, the City Electrician, happily explained Wireless Telegraphy, a subject of bewilderment to those whose daily observation led them to suppose a net-work of telegraph and telephone wires was essential to the control of electrical impulses conveying definite signals; and in this subject local interest has been excited by the selection of Glace Bay, Cape Breton, as the station for transatlantic communication. The great trouble to which Mr. Colpitt went to illustrate his subject, and his success, were fully appreciated by his audience.

Professor E. E. Prince, Commissioner of Fisheries, Ottawa, explained the colors of animals, their nature and meaning, by the aid of numerous lantern slides, which excited general admiration. The apparatus used to show the slides of Professor Prince and Dr. Woodman was generously supplied and operated by Mr. Jenney. Professor Prince also presented a paper on the Swim Bladder of Fishes, which he described as a degenerate gland.

Geological subjects furnished the text of several papers: The Meso-Carboniferous Age of the Union and Riversdale Formations of Nova Scotia, and their equivalents the Mispec and Lancaster Formations of New Brunswick, by Dr. Ami, of Ottawa; a note on *Dictyonema Websteri*, was read by Mr. Poole, of Halifax, who also submitted comments on the question,—Is there coal under Prince Edward Island? as a companion paper to the official report on the allied subject by Dr. Ells, of Ottawa, an officer of the Geological Survey of Canada. The Geology of Moose River Gold District, N. S., was explained by Dr. Woodman; and Dr. Gilpin, the Government Inspector of Mines, gave analyses and sections of Nova Scotia coals, and also presented a paper on the Mira Grant. Mr. C. B. Robinson, of Pictou Academy, described a Lichen-mimicing Caterpillar, and also noted the Distribution of *Fucus serratus* in Nova Scotia.

The Kings County Branch of this Institute, under the direction of Professor E. Haycock, of Acadia College, discussed a number of subjects as mentioned in its report on p. xxv.

APPLICATION OF SCIENCE TO MINING.

Having been a worker among the mineral products of the province, it is natural for me to turn in that direction for matter on which to address you to-day. All of us have been constantly reminded during

the past three years of the keen and wide-spread interest taken in our chief mineral export—coal, and our principal mineral import—iron ore. The disturbing influence which accompanied the rapid development of iron and steel plants, and the re-equipment of old, and the establishment of new collieries, affected all classes, and largely those which had grown up since the local gold fever was epidemic in the late sixties. The influence of general prosperity stimulated search for mineral wealth in every direction, including the improbable and impossible, regardless of the pessimistic records acquired in the interest of science, without monetary stimulus. The onlooking student can learn much of human nature by observing the ready acceptance of alluring promises made by designing or untrained promoters, while the cautious utterances of the experienced are waved aside. The unit in the army of searchers, that the law of averages makes successful, is individualized and quoted as an authority by the rest, pitted as it were against individuals from the ranks of science, whom the same law would allow to blunder, or be unfortunate, without detriment to the correctness of a general truth.

And yet, of late, public confidence has been shown to a surprising degree, in some general deductions of a scientific nature, when it was assumed their successful application might result in financial success. The investigations of Mr. H. Fletcher of the Geological Survey in Cumberland and Colchester Counties, have made it possible that the views hitherto held on the structure of that region might be erroneous, and they have justified a letter I wrote to a member of parliament in 1894, urging a re-survey of that ground; and when this change of view, the result of Mr. Fletcher's explorations was realized, a boom was created, and application for mineral rights over the entire area brought in large sums to the provincial coffers, the supposition now being held that extensions of the thick seams of Springhill may possibly occupy in depth the basins east and west of that elevation and to the northward of the Cobequid Hills. To prove this theory, bore-holes to considerable depths and systematically placed, alone can determine the correctness of the hopes indulged in.

Mr. Fletcher's examination goes to show that the upper members of the series continue to the Cobequid Hills, without a reappearance at the surface of the underlying Millstone Grit as was assumed on the

map of 1884. The rush for areas did not stop in Cumberland County, but passed into Colchester and Pictou, and along the shore of Minas Basin, where small coal seams have been discovered for half a century or more. To some of these localities no countenance has been given by the survey, but encouragement by the prospector is taken on the ground that the first Pictou Coal Field map was at fault east of the Drummond Mine, and cut the coal field off too soon. This, it may be explained, arose from credit for accuracy being given to maps of early explorations made on behalf of the Drummond Mine, which late mining operations have failed to confirm. Speculation once awakened on these lines, hope, eternal hope, has underlaid the greater part of the Permian series in the latter counties with concealed coal wealth, and this view has been given official sanction in the catalogue of the minerals at the late Provincial Exhibition. It will, however, be well to remember, that that the Permian is known to rest in places directly on Millstone Grit rocks, and that further study of the sub-Permian structure and faulting is advisable before extensive explorations by bore-holes are conducted. Ideas of what this structure may be in parts, have been suggested by the work already done in the field, but any reference would be altogether premature at the present time, and before full counsel has been taken with men who have made a special study of great continental movements.

In the mining of gold, a marked degree of confidence has of late grown round certain theoretical deductions. It may even be said that the conclusions reached by Mr. E. R. Faribault, working in our gold districts on behalf of the Geological Survey, have been accepted by the rank and file of the miners as proven.

It was not very long after the public recognition, in 1860, of the presence of gold in paying quantities, that Mr. John Campbell, a local geologist, noted a regularity in the foldings of the strata, and that many of the leads, which on account of their richness had attracted the gold seekers, centred about anticlinal folds. Professor H. Y Hind, about 1872, on behalf of the provincial government, extended these ideas, but the ordinary prospector, for a time, preferred to let chance govern his movements, and let those who chose to theorize come after him. In early days the theorist had no following, and if he failed to make a strike it was his fault and not his misfortune,

while if one of the great army of prospectors was singled out by the law of averages, or was smiled on by the fickle goddess Chance, the fortunate one so selected, became in the eyes of his fellows an expert.

Then it was, too, when the foreign miner criticised the skill of the native ; while lavishly praising the richness of the district, singular to say, he forgot to take advantage of his opportunity, apply his vaunted knowledge, and make a fortune for himself.

Summing up the experience of the first twenty years of mining in the province, in general language it may be said that each paying lead had yielded but one pay-streak, and when that was extracted, further search had failed to disclose others in the same lead. The work of collecting data relating to the structure of the gold field, and the mode of occurrence of the mineral contents, dropped by the local Department of Mines, was taken up by the Geological Survey under direction from Ottawa, and now what patient investigation has revealed is that leads other than those seen at the surface may confidently be expected to be within reach of shafts sunk on the anticlines, where the saddles of quartz will have their greatest thickness ; and secondly that pay-streaks will be found to have a well-defined relation to one another and to the axis of the anticline, together defining for each gold district a zone of special enrichment. Evidence on both these points has been given in the papers published with illustrations in the transactions of the Mining Society of Nova Scotia, and which explain the maps and sections issued by the Geological Survey in the meantime, and until the final report on the gold fields has been prepared.

Mr. Faribault having surveyed the field, noted the folds and their faulting, and the relation of the pay streaks, with the result that he found a structure after the manner of that at Bendigo, but on a larger scale : a series of saddles of quartz, sitting on the axis of the anticline, one over the other, in the spaces formed between the folded strata. Parallel with the axes, he claims there are inclined zones of enrichment, which passing from lead to lead in their courses, leave in each a pay-streak of definite extent. If these conclusions are generally confirmed in practice, the gold mining industry would be placed on a more secure footing, much of its late restricted aspect removed, and great inducement given to companies of sufficient capital to operate under judicious management.

In the field of metallurgy a question has arisen, which, so far, has not been satisfactorily answered. It has been found that of the gold associated with the antimony ores of West Gore, one-half of the assay value goes with the quartz tailings, which can be treated for the gold in one or the other usual ways. The other half of the gold values remains with the antimony concentrates, aud the question is how to separate the two metals and obtain a high return for both.

Papers on the composition of many provincial minerals are given in various publications, accurate enough, doubtless, in themselves, but, where of commercial value, often lacking in some of the details which are essential to a full appreciation of the analyses. For instance, one may find specimens of chalcopyrite labelled as containing 30 per cent. of copper, a percentage that tells the mineralogist it is merely an assay of the richest portions picked out, and cannot be of an average sample of a deposit, as the uninitiated may be led to believe.

Again, in coal, in some of these analyses the percentages of ash and sulphur shown do not agree with the practical results obtained by the user and coke maker. They are too low, and this being well known the chief purpose they serve is to bring discredit on any carefully made reports with which they may be associated. Distrust once aroused it is difficult to get confidence restored, and the only remedy seems to be in accurately stating the associated circumstances, whether the result is obtained from a hand-picked specimen or from a specified quantity of ore properly sampled down ; or if of a coal seam, then of a strip taken from top to bottom.

Men of experience are hence apt to ignore all analyses of the class referred to, not endorsed with the name of the analyst, and to insist on independent investigation ; while there are others less experienced, who deceive themselves, and being of a sanguine temperament, mislead others. No good purpose is served by this, and the country at large is not benefitted. The Mining Society has had this matter under consideration, and has advocated the appointment of a provincial assayer, who, by the way, might well be also government instructor in the schools of higher mining, which, it is felt, are much needed in this province, to be associated in the work so well begun by Dalhousie University.

The Treasurer's report was presented, and having been audited and found correct, was received and adopted. The following is an analytical statement of the expenditure for 1902-1903 :

PUBLICATION OF TRANSACTIONS :—		
Vol. X , Part 3, (1900-1901) :		
Printing	$ 247 60	
Engraving (Jones portrait)	6 00	
Wrappers	3 00	
Vol X., Part 4, (1901-1902) :		
Printing	274 44	
Engraving (Downs portrait)	3 75	
Wrappers	3 00	
		$537 79
DISTRIBUTION OF TRANSACTIONS :—		
Vol. X., Part 3 :		
Freight	$ 1 38	
Insurance	1 00	
Postage	10 25	
Vol. X , Part 4 :		
Addressing and supervising distribution	15 00	
Packing boxes	4 50	
Insurance	1 00	
		33 13
MEETINGS :—		
Advertising annual meeting	$10 00	
Post cards and printing	36 25	
Chairs	16 50	
Electrical work and carpentry	7 68	
Truckage	4 25	
		74 68
Expressage on books received	1 20	
Grant to Secretary	50 00	
Postage (Secretary)	98	
Telegrams	2 11	
Typewriting report to Royal Society	75	
Letter heads	2 25	
Receipt book	2 50	
File	1 20	
Photograph of R. Morrow	1 50	
Painting blackboard	2 50	
		64 99
		$710 59

The Librarian's report was presented and adopted.

A report was read from PRESIDENT ERNEST HAYCOCK, of the KINGS COUNTY BRANCH OF THE INSTITUTE, Wolfville, N. S., on the work done by the branch during its third session (1902-03). Meetings were held and papers read as follows:

10th February, 1903.

1. Review of previous year's work and suggestions for the future.—By PRESIDENT HAYCOCK.
2. Election of officers:

   President: PROFESSOR ERNEST HAYCOCK.
   Vice-President: PROFESSOR E. W. SAWYER.
   Secretary-Treasurer: PROFESSOR F. C. SEARS.
3. Principles of the Dynamo.—By PROFESSOR F. R. HALEY.

10th March, 1903.

4. Systems of Electric Lighting.—By D. R. MUNRO.
5. Dr. Alolf Loring and his Specialty.—By A. DEW. BARSS, M. D.
6. Retreat of the Coast of Minas Basin at Long Island, Kings Co., N. S.—By PROFESSOR E. HAYCOCK.

21st April, 1903.

7. Ice-borne Sediment in Minas Basin—By J. A. BANCROFT. (See Transactions, p. 158).
8. Teaching Material in Mineralogy recently added to the Acadia College Collection.—By PROFESSOR E. HAYCOCK.
9. Life History of the Bud Moth.—By PROFESSOR F. C. SEARS.

The report was received and adopted.

It was resolved that the thanks of the Institute be conveyed to the HON. SIR ROBERT BOAK, for his courtesy in granting the Society the use of the Legislative Council Chamber as a place of meeting; and to the SECRETARY OF THE SMITHSONIAN INSTITUTION for continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

The following were elected officers for the ensuing year (1903-1904) :

President,—HENRY SKEFFINGTON POOLE, D. Sc., A. R. S. M., F. G. S., F. R. S. C , *ex officio* F. R. M. S.

Vice-Presidents.—F. W. W. DOANE, C. E., and PROFESSOR EBENEZER MACKAY, PH. D.

Treasurer,—WILLIAM MCKERRON.

Corresponding Secretary,—A H. MACKAY, LL. D , F. R. S. C.

Recording Secretary, —HARRY PIERS.

Librarian,—HARRY PIERS.

Councillors without Office,—MAYNARD BOWMAN, B A.; WATSON L. BISHOP; MARTIN MURPHY, C. E , D. Sc. ; PROFESSOR STEPHEN M. DIXON, B A., B. A. I ; EDWIN GILPIN, JR , LL. D , F. R. S. C ; ALEXANDER MCKAY ; PROFESSOR J. E. WOODMAN, D. Sc

Auditors, —RODERICK MCCOLL, C. E ; J. B. MCCARTHY, M. A., B. Sc.

FIRST ORDINARY MEETING.

Legislative Council Chamber, Halifax, 16th November, 1903.

THE PRESIDENT, DR. H. S. POOLE, in the chair.

It was announced that MAJOR-GENERAL CAMPBELL HARDY, R. A., of Dover, England, had been elected a corresponding member, and that D. BUDGE, General Superintendent of Halifax and Bermuda Cable Company, Halifax, had been elected an ordinary member.

VICE-PRESIDENT MACKAY took the chair while the PRESIDENT, DR. POOLE, read a paper " On the Age of the Conglomerate capping the Cambrian Rocks of Nova Scotia." (See Transactions, p. 236). The subject was discussed by DR. WOODMAN, DR. A. H. MACKAY, H. PIERS, T. V. HILL and W. H. PREST.

W. C. MILNER exhibited the manuscript of a geological map of Nova Scotia, which will be issued with the mining number of the " Nova Scotian."

SECOND ORDINARY MEETING.

Legislative Council Chamber, Halifax, 21st December, 1903.

THE PRESIDENT, DR. POOLE, in the chair.

It was announced that the following had been elected ordinary members : JAMES H. WINFIELD, Manager N. S. Telephone Company,

Halifax; GEORGE M. J. MACKAY, Dartmouth, N. S.; PROFESSOR DANIEL A. MURRAY, Dalhousie College, Halifax; PROFESSOR FREDERIC H. SEXTON, Dalhousie College, Halifax.

DR. A. H. MACKAY took the chair while the PRESIDENT read a paper by KENNETH MCINTOSH, C. E., St. George's Channel, N. S., "The Question of Subsidence at Louisbourg, C. B.", with introductory notes by the reader. (See Transactions, pp. 262 and 264). The paper was illustrated by a map of a recent survey of Louisbourg made by MR. MCINTOSH, and also by some old plans. The subject was discussed by DR. H. H. READ, DR. A. P. REID, H. PIERS, DR. WOODMAN and DR. MURPHY.

T. VARDY HILL read a paper on "The Creation and Development of the Inorganic Foundation of the Earth." The subject was discussed by DR. WOODMAN, and a vote of thanks was presented to MR. HILL.

THIRD ORDINARY MEETING.

Provincial Science Library, Halifax, 11th January, 1904.

DR. A. H. MACKAY in the chair.

On motion of H. PIERS and Dr. A. P. REID, it was resolved that the Nova Scotian Institute of Science learns with deep regret of the death of AUGUSTUS ALLISON, Dominion Meteorological Agent at Halifax. Mr. Allison was one of its oldest members, having been elected in February, 1869, was a former vice-president, and for a long period a member of the council. It was further resolved that the Secretary be instructed to send a copy of this resolution to the family of the deceased.

CAPTAIN J. H. BARBOUR, M. B, Royal Army Medical Corps, Halifax, read a paper on "Local Variations and other Notes on Blue-eyed Grass, *(Sisyrinchium angustifolium)*." (See Transactions, p. 190). The subject was discussed by the CHAIRMAN and others, and a vote of thanks was presented to DR. BARBOUR.

Owing to the unavoidable absence of the PRESIDENT, who was to have taken part in the discussion on the subject, DR. J. E. WOODMAN's paper on the "Origin of Peneplanes" was postponed, and he gave instead a lecture on "Drainage Development of Rivers." The subject was discussed by several of the members, and a vote of thanks was passed to the lecturer.

Fourth Ordinary Meeting.

Legislative Council Chamber, Halifax, 10th February, 1904.

The Institute met in conjunction with the Canadian Forestry Association, the chair being occupied by Dr. A. H. MacKay, Nova Scotian Vice-President of the Forestry Association.

"Addresses on Forestry" were given by E. Stewart, Dominion Superintendent of Forestry, and R. H. Campbell, Assistant Secretary of the Forestry Association, both of Ottawa. Mr. Stewart's lecture was illustrated by lantern views.

The subject was discussed by the Chairman, Hon. J. W. Longley, Dr. M. Murphy, and Hon. Wm. Chisholm, M. L. C.; and a vote of thanks was passed to Messrs. Stewart and Campbell.

Fifth Ordinary Meeting.

Legislative Council Chamber, Halifax, 14th March, 1904.

The President, Dr. Poole, in the chair.

A paper by Frank H. Reid, on "Birds and the Selection of their Nests" was communicated by Dr. A. P. Reid. The subject was discussed by R. H. Brown and W. L. Bishop, and a vote of thanks was presented to the writer.

Mr. Piers read a paper by Henry Youle Hind, M. A., D. C. L., of Windsor, on "The Importance of a Knowledge of Rock Foldings to Miners." The paper was discussed by Dr. Woodman and Mr. Piers; and a vote of thanks was passed to Dr. Hind.

T. Truman Fulton, B A., read a paper on "The Faults of Battery Point, Sydney, C. B.", illustrated by a section of the strata under consideration. (See Transactions, p. 260). On motion, a vote of thanks was presented to Mr. Fulton.

The following paper was then read, by title :—"The Structure and Succession at North Sydney, C. B.", by Loran A. DeWolfe, M. A., North Sydney; being communicated by Dr. Woodman. (See Transactions, p. 289).

Sixth Ordinary Meeting.

Legislative Council Chamber, Halifax, 11th April, 1904.

The President, Dr. Poole, in the chair.

Alexander McKay took the chair while the President read a paper entitled "The Sunken Land of Bus (lat. 35° west, long. 53° north)." (See Transactions, p. 193). The subject was discussed by Dr. Woodman, Dr. A. P. Reid, J. Adams, First Officer of Cable S. S. "Minia," and H. Piers.

A paper by Francis H. Mason, F. C. S , metallurgist, Halifax, entitled, "Notes on Hydraulic Lime and Cement," was read by the President. (See Transactions, p. 179). The subject was discussed by Professor F. H. Sexton, J. W. McKenzie, Professor Woodman, the President, and H. Piers.

The following papers were read by title:—

"Contributions to the Study of Solution of Hydroxylamine and its Salts," by W. H. Ross, B. Sc. (See Transactions, p. 95).

"Structure of the Meguma (Gold-bearing) Series, with reference to the Theory of Cross-folds," by Professor J. E. Woodman, D. Sc., Dalhousie College.

"The Earthquake of March 21, 1904, in the Maritime Provinces," by Professor Woodman. (See Transactions, p. 227).

Seventh Ordinary Meeting.

Legislative Council Chamber, Halifax, 9th May, 1904.

Professor Stephen M. Dixon in the chair.

Dr. A. H. MacKay read a paper entitled "Phenological Observations in Canada, 1903." (See Transactions, p. 271). The subject was discussed by Dr. Barbour, R. A. M. C., who compared the time of flowering of plants in Nova Scotia and England.

A paper by Professor J. E. Woodman, D. Sc., Dalhousie College, entitled "Bibliography of the Meguma (Gold-bearing) Series of Nova Scotia," was read by title.

The council was authorized to receive, as read by title, such papers as may be presented too late for this meeting.

Harry Piers,
Recording Secretary.

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1904-1905.

ANNUAL BUSINESS MEETING.

Legislative Council Chamber, Halifax, 17th October, 1904.

THE PRESIDENT, DR. HENRY S. POOLE, in the chair.

PRESIDENTIAL ADDRESS: (1) PROGRESS OF THE INSTITUTE, (2) BORINGS IN SEARCH OF COAL. BY HENRY S. POOLE, D. SC., ASSOC. ROY. SC. MINES, F. G. S., F. R. S. C., HON. M. I. M. E., &C.

The honor, I have had of being your chairman for a second term, gives me again the privilege of reporting the work of the past session, and an opportunity to lightly touch on the papers submitted.

Progress of the Institute.

Besides the regular monthly gatherings, a special meeting to hear papers by Mr. E. Stuart and Mr. R. H. Campbell, of Ottawa, on Forestry, illustrated by drawings enlarged on a screen, appealed to popular taste.

The subject matter of the papers at the ordinary meetings covered a wide range, as might be expected from a maritime people with diversified interests and familiarized by easy travel with the littoral of many lands. The consideration of time and its effects during periods that extended back into thousands of centuries, created no surprise; and geological questions, chiefly of local bearing, furnished subjects for one-third of the papers presented to the Institute.

Zoology found an exponent in Mr. Frank H. Reid who had many interesting things to say on the nidification of some of our birds.

Chemistry was not neglected. Mr. F. H. Mason gave notes on provincial hydraulic lime and cement, and Mr. W. H. Ross contributed the results of a study of solutions of hydroxylamine and its salts.

Botanical studies were shewn not yet to have been carried to exhaustion, for Capt. J. H. Barbour, A. M. C., on the local varieties of blue-eyed grass, suggested a new line of comparison. The value of combined observation conducted under experienced supervision by public school children was noted in the further additions to phenological records laboriously compiled by Dr. A. H. MacKay.

The veteran, Dr. H. Y. Hind, dwelt on the importance to miners of a knowledge of rock foldings; and the new science courses at Dalhousie College bore fruit in papers by two students, Mr. T. T Fulton writing on the Faults of Battery Point, Sydney, and Mr. L. A. DeWolfe on the cliff sections at North Sydney; papers indicating careful record of close observation. Dr. Woodman gave the bibliography and an exhaustive review of the gold-bearing rocks of Nova Scotia which he proposed should be designated "Meguma." The same gentleman recorded the earthquake shocks which were observed in parts of the Maritime Provinces in March of the present year. A criticism of the long received view that Louisbourg supplied evidence of very recent subsidence came from the pen of Mr. Kenneth McIntosh and met with general acceptance. To the writer was given an opportunity to ask for a review of the age of the conglomerate here and there capping the Cambrian rocks of the Atlantic coast. It was also given to him to speak of the "Sunken Land of Bus," where the cabled depths of mid-ocean recalled the ancients' story of the fabled Atlantis.

Mr. T. Vardy Hill referred to the creation and development of the foundation of the earth, and in this country was also heard an echo of the revived discussion of the relation of scientific studies to religious beliefs and something of the progress made among the foothills of knowledge by such seekers after truth as have met the outposts so long and strongly held by theological teachers. While by the bulk of our people the views of forty years ago are still

unchanged, by students of both classes mutual forbearance is practised and they are content to work side by side, although it is evident both could not agree were they to continue to an issue the deductions to which several of their teachings lead. We as a society cannot well engage in controversies of this character, for it is not to be expected that where individual convictions are involved that members as a body could maintain a judicial position and a tolerant spirit.

Note also was taken of the interest in scientific research by the Branch of the Institute established in King's County and the additional five papers that were discussed at Wolfville.

Borings in search of Coal.

In my address of a year ago I referred to certain theoretical deductions respecting the possible extension of workable coal seams lying concealed under newer measures on the north side of the Cobequid hills from the Bay of Fundy eastward to Merigomish.

The interest that had there been aroused took practical shape, and search in three localities was prosecuted. One borehole was put down at Spicers' Cove on the Bay of Fundy to a depth of 944 feet, but as it turned out, it was placed too close to the hill range, for after passing through a thick bed of conglomerate, largely composed of the debris of the old rocks it entered, at 893½ feet, igneous rocks in place. A site for another hole in this locality has been selected further from the hills, at Apple river.

The second locality is near Newville at Halfway River lake on the Springhill and Parrsborough railway, and a borehole there also met with conglomerate at the expected depths. Here it is found to be composed chiefly of clastic rocks of Lower Carboniferous age, and it has not yet been passed through by the borehole which has now reached a depth of over 2200 feet.*

The third persistent effort to get at the underlying strata was made at the mouth of Rear brook, below New Glasgow, on the East river. After the loss of the first hole at a depth of some 900 feet a second borehole was made alongside the first, and at 1900 feet it had failed to reach the bottom of the conglomerate bed when

* Subsequently, at 2350 feet from the surface coal was struck which is reported to be 9 feet in thickness, and the boring was stopped at a depth of 2359 feet.—*Ed.*

misfortune again met the borers and the hole was hopelessly lost. Another 100 feet would have got down to the underlying beds according to calculations based on surface outcrops.

The Treasurer's report was presented by MR. MCKERRON, and having been audited and found correct, was received and adopted.

The Librarian's report was presented by MR. PIERS. During the year 1904, 2330 books and pamphlets had been received and catalogued The total accessions of the Science Library, with which that of the Institute is incorporated, were 3,115 for the year. The report was received and adopted, and a vote of thanks was presented to Mr. Piers for his services.

A report was read from the KING'S COUNTY BRANCH OF THE INSTITUTE, Wolfville, N. S., on the work done by the Branch during its fourth session (1903-04). The officers of the branch were as follows:

President,—PROFESSOR ERNEST HAYCOCK, M. A.
Vice-President,—PROFESSOR F. R. HALEY, M. A.
Secretary-Treasurer,—PROFESSOR E. W. SAWYER, B. A.

The following papers, etc., were communicated to the branch:

1. Constitution of Matter. (General discussion.)
2. The Atomic Theory of Dalton.—By PROFESSOR E. HAYCOCK, M. A.
3. The Divisibility of the Atom.—By PROFESSOR F. R. HALEY, M. A.
4. Influence of Climate on Fruits.—By R. W. STARR.
5. The Black Knot of the Plum.—By PROFESSOR F. C. SEARS.

The report was received and adopted.

It was resolved that the thanks of the Institute be conveyed to the HON. M. H. GOUDGE, President of the Legislative Council, for his courtesy in granting the society the use of the Legislative Council Chamber as a place of meeting during the past session; and to the SECRETARY OF THE SMITHSONIAN INSTITUTION for continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

The following were elected officers for the ensuing year (1904-05):

President,—HENRY SKEFFINGTON POOLE, D. Sc., A. R. S. M., F. G. S., F. R S C., *ex officio*, F. R M. S

Vice-Presidents,—F. W. W. DOANE, C E., and PROFESSOR EBENEZER MACKAY, PH D.

Treasurer,—WILLIAM MCKERRON.

Corresponding Secretary,—A. H. MACKAY, LL. D., F R. S. C.

Recording Secretary,—HARRY PIERS.

Librarian,—HARRY PIERS

Councillors without Office,—MAYNARD BOWMAN, B A.; WATSON L BISHOP; PROFESSOR STEPHEN M. DIXON, B. A., B. A. I; EDWIN GILPIN, JR., LL. D, F. R. S, C., I. S. O; ALEXANDER MCKAY; PROFESSOR J. EDMUND WOODMAN, D. Sc.; J. B. MCCARTHY, M. A., B. Sc

Auditors,—RODERICK MCCOLL, C. E.; and PROFESSOR F H SEXTON.

DR. MACKAY took the chair while the President, DR. H. S. POOLE, read a paper on "Pre-Cambrian Volcanic Bombs from near Lake Ainslie, Inverness Co., N. S." (See Transactions, p. 339).

DR. WOODMAN gave the result of a microscopic examination of some of these bombs.

FIRST ORDINARY MEETING.

Legislative Council Chamber, Halifax, 21st November, 1904.

THE PRESIDENT, DR. H. S. POOLE, in the chair.

PROFESSOR STEPHEN M. DIXON, M. A., B. A. I., read a paper entitled, "A Determination of the Elements of Terrestrial Magnetism at Halifax, N. S., August, 1904." (See Transactions, p. 245). The subject was discussed by the PRESIDENT, and DR. A. H. MACKAY and DR. WOODMAN, and a vote of thanks was presented to the lecturer.

SECOND ORDINARY MEETING.

Legislative Council Chamber, Halifax, 23rd January, 1905.

The PRESIDENT, DR H. S. POOLE, in the chair.

The RECORDING SECRETARY announced that the REV. BROTHER JUNIAN PETER of Fall River, Mass., U. S. A., a corresponding member, had presented to the Institute a collection of dried plants collected in his district. The Secretary was directed to convey to Brother Peter the thanks of the society.

PROFESSOR J. EDMUND WOODMAN, D. SC., gave a lecture on "The Volcanoes of the Hawaiian Islands," illustrated by coloured lantern-slides. A vote of thanks was presented to the lecturer.

Third Ordinary Meeting.

Provincial Science Library, Halifax, 13th March, 1905.

The President, Dr. Poole, in the chair.

It was announced that Captain E. B. Tinling, R. N., of the Marine and Fisheries Department, Halifax, had been elected an ordinary member.

The Recording Secretary reported that there had been received from the Royal Society of London, forty volumes of its earliest Proceedings (from vol. 1, 1800) so far as they were in print. It was directed that the thanks of the Institute be conveyed to the Royal Society for this valuable gift.

In the absence of the author, Dr. A H. MacKay read a paper by Walter H. Prest of North Brookfield, N. S., on "Edible Wild Plants of Nova Scotia." (See Transactions, p. 387). The subject was discussed by Drs. A. H. MacKay, Poole, Barbour, A. P. Reid, and Messrs. Piers, Bishop, Harris, and others. A vote of thanks was presented to Mr. Prest for his paper.

Dr. J. E Woodman read by title a paper entitled "Distribution of Bedded Leads in relation to Mining Policy." (See Transactions, p. 163).

Fourth Ordinary Meeting.

Assembly Room, Province Building, Halifax, 17th April, 1905.

The President, Dr. Poole, in the chair.

It was announced that L. C. Harlow, B. Sc., Provincial Normal School, Truro, N. S., had been elected an associate member.

The Recording Secretary announced that the Proceedings and Transactions of the Institute, vol. xi, part 1, had been published and part 2 was now in press.

In the absence of the author, Dr. Woodman read a paper by M. V. Grandin of Cheticamp, entitled, "Notes on the Ore Deposits of South Cheticamp, Cape Breton Island, N. S." (See Transactions, p. 347). The paper was discussed by the President, Dr. Woodman, and others ; and a vote of thanks was presented to the author.

F. H. McLearn read a paper, entitled, "A Structural Analysis of the Goldenville Anticline, Guys. Co., N. S." The subject was discussed by J. Regan, H. Piers, Dr. Woodman, and Professor Haycock ; and a vote of thanks was presented to Mr. McLearn.

FIFTH ORDINARY MEETING.

Assembly Room, Province Building, Halifax, 16th May, 1905.

DR. A. H. MACKAY, in the chair.

The RECORDING SECRETARY reported that the Council had appointed the Treasurer, WM. MCKERRON, to represent the Institute at the forthcoming meeting of the Royal Society of Canada.

PROFESSOR J. E. WOODMAN, D. Sc, presented two papers: (1) "Note on Crystallized Gold"; (2) "Detection of Vanished Coastal Plains."

The following papers were read by title :—

"Phenological Observations in Nova Scotia and Canada, 1904," by A. H. MACKAY, LL. D., F. R. S. C. (See Transactions, p. 373).

"Meteorological Notes," by F. W. W. DOANE, C. E. (See Transactions, p. 361).

"Weathering of Building Stone in Halifax," by PROFESSOR J. E. WOODMAN, D. Sc.

HARRY PIERS,
Recording Secretary.

PROCEEDINGS

OF THE

Nova Scotian Institute of Science.

SESSION OF 1905-1906

Annual Business Meeting.

Legislative Council Chamber, Halifax, 18th October, 1905.

The President, Dr. Henry S. Poole, in the chair.

Presidential Address.—By Henry S. Poole, D. Sc., F. R. S. C.

The Institute's Work.

We are once more met together to hold an annual meeting, to receive reports, elect officers for the ensuing year, and open another session of this Institute. During the year that has closed, we suffered no loss of members, and the interest taken in the meetings remained at the standard customary of late.

The additional movement established a few years ago, viz. the popularizing of special meetings, has been continued with a gratifying attendance. Advantage was taken, through Mr. Jenney's kindness in placing his electric-lantern at the service of the Institute, the better to display the carefully prepared and attractive illustrations of volcanoes which Dr. Woodman was enabled to use at his lecture to an appreciative audience. It will be noted that half the papers read and submitted at the last session were more or less geological. This should create no surprise in a province so given over to mining, and possessed of so wide a range of strata well exposed for study. Of a different class was the paper of Mr. W. H. Prest on "Edible Wild Plants of Nova Scotia," which brought to

the meeting when it was read, many members of the Botanical Club of Halifax, and which led to a discussion of much interest, that showed that all had not been learned of the twigs, leaves, barks and roots, which in cases of emergency would be available to sustain life. The facts brought out at the discussion, in addition to those given by the author, suggest that much good would ensue at future meetings were the custom established of getting members and their guests to submit in writing, for publication with the primary paper, remarks thereon. Not only would a writer be gratified by the notice his article elicited, even when there was not entire agreement, but the subsequent reader of the paper would have also a knowledge of the measure of credence or endorsement given to the statements made at the time of presentation.

It was most unfortunate that the Kings County Branch of the Institute, at Wolfville, was unable to hold meetings during the year. This was due, however, to no lack of interest in the branch, which was organized in 1901.

The finances of the Institute have received the careful attention of the Treasurer, and his report will be submitted:

The Recording Secretary, I was on the point of writing, gave me invaluable assistance in the work of calling the meetings, preparing statements, keeping accounts and editing the transactions; but I am sorry to say I cannot truthfully do this, for it was not merely assistance that I got from him. The fact is, he was the head and front of the Institute the past three years, and saw to everything. We have taken so much as a matter of course the services he has given, that I fear we have not fully appreciated the sacrifices he has made, sacrifices which the Institute cannot expect to continue forever, especially as he has duties in other directions which are constantly growing. His is an interesting case of early training to a sense of moral obligation, that I am selfishly thankful extended to the end of my term of office, and I now would make all due acknowledgments.

Speculative Thoughts.

And now before giving place in this chair to a busy man of practical ideas, let me give utterance to a few vague speculations of idle moments.

When man wakes to consciousness in this material world, he finds himself one of many varied organisms, stamped with one general plan, automatic in part, and also in possession of a limited amount of free-will and action. As he becomes sensible of his position, and his bodily wants are met, he begins to realize he is not so very independent or all-powerful, and that he is living on a borderland of mysteries, surrounded by the inexplicable, and when considered from a purely personal point of view, by what seem malevolent as well as benign influences. The limitation to his powers meets him on every hand, and he finds his very existence depends on the range of the forces to which he is exposed being circumscribed. He finds, moreover, his consciousness of sensation also has its limits, as of sound proceeding from pulsations only within fixed amplitude and frequency, the limit of perception varying somewhat with the individual, in harmony with the variability of moderate degree everywhere observable in nature. Light and heat also have to be restricted in their range if they are to be utilized by man, while excess of the latter is made evident beyond doubt by destruction of tissue.

At times man glories in the freedom he possesses, and especially when he makes subservient to himself beings weaker or mentally less endowed, beings whose sum of animal existence is to eat and to be eaten, for few individuals in the ferine state escape the latter condition, and, as a matter of fact, few animals of any condition.

As consciousness develops, and with a mind free of anxiety for immediate wants, he seeks to know who and what he is in this world's economy, whence he has come, and whither will he go. His untrained perceptions failing him beyond the compass of self-preservation, he consults his fellows for their knowledge of these matters. He becomes a student and so far as his enquiries and experiments are systematic, a student of science.

Here, as in all cases of disturbance, whether physical or mental, opposition is met with, and the student of truth has to contend with errors of observation and assumption of conclusions unproved. The latter especially hampers him, for recognizing his seeming hopeless ignorance of much there is about him, he is only too ready

to accept the confident assertion of another individual grasping every opportunity for self aggrandizement.

As a student he has first to carefully confine his observations to that which is material and to oft trodden paths, to accept nothing as true which cannot be put to the test over and over again, since isolated cases, however suggestive of the truth of certain contentions, may mislead when all conditions of a problem have not been noted. Further than this faith in the teachings and reverence for the fathers of modern science are not inculcated to pass beyond respect. Their deductions of yesterday are subject to the cold criticism of to-day equally with the latest theory of the youngest tyro: and as for flights of fancy and the poet's glamour, they are not needed to enhance admiration, awe and wonder of the mysterious marvels that unfold themselves to his growing intelligence.

In the schools of chemistry and physics, natural phenomena have no sporadic mysteries, though their controlling source be obscure, and vast ignorance respecting them necessarily still prevails. Repeated proof is essential, since fortuitous concurrences mar the accuracy of findings based on solitary examples. The world is full of superstitions derived from hasty generalizations, and many have come down from pagan times and been engrafted with modern belief.

The teachings of the nursery, with its first and indelible impressions, have a lasting effect, and we grow up creatures largely of habit, indisposed to put aside pre-conceived opinions and even perhaps unable to dispassionately consider, on their merits, questions touching ourselves. This innate tendency of the mind to keep alive the lore impressed in childhood and clung to generation after generation, is in keeping with ancestral characteristics of the body which we note in ourselves and our neighbours, and which the breeder of choice strains of animals and plants is particular to propogate.

The unbiassed student will take the stand that the intelligence with which he is endowed calls for it exercise and growth; that he is warranted in searching into all that appertains to himself and his surroundings, although his powers are restricted and he is incapable of reducing to order a fraction of the mysteries about

him; unable to grasp an idea either of creation or annihilation, or a condition preceding the one and succeeding the other, or of a beginning or ending of time or limitation of distance. While there is much that he cannot hope to understand, there are suppositions he cannot possibly accept, as that of birth without resultant death, nor can he conceive of mental sensations, as joy, love and hope, without crediting the converse possibilities. There would be for him no pleasure if there were no pain, no recognition of light without that of darkness, nor of heat without cold. The perception of the one necessarily demands the condition of the other. All nature teaches this to be a truth, analogy with cause and effect, is everywhere constant, whether it be among phenomena typified by the satisfying of an acid for its base, or among an entirely different group exemplified in the fatigue which follows strain.

Reverting for a moment to pain, to excruciating pain, which some people tell us they find hard to reconcile with their standard of faith, let us picture a stricken creature, the moment before stored with vitality, now the innocent victim of an accident which deprives his nervous energy of control, and lets loose the impulses which ordinarily are used only slowly as required for the well-being of the body. No longer under restraint, these become intensified with a correspondingly rapid exhaustion of vitality, and the dews of anguish mark that intensity as beyond endurance. It is like the burning of a candle at both ends in oxygen, the sum total of stored energy is there used up in a very short time.

When the student awoke to the value of classifying his observations and realized that order prevailed even among details apparently dissimilar, great advance was made, and he was then able to satisfy himself by repeated experiment that phenomena of nature were subject to fixed relation which could be expressed as laws, and he was also able to convince his fellows that, under similar treatment, like results would ensue in their hands.

Besides the phenomena he has systematized, he reasonably assumes by analogy that there are others equally amenable to elucidation, although efforts in many directions have so far met with but indifferent success.

Retrospection raises hope to pursue further investigation among the unexplained mysteries even of the organic world. Who a century ago would have thought it possible to harness lightning to a car, to prove a similarity of chemical elements in other worlds than ours, to see with ordinary vision through walls of common brick, to hear a whisper along one thousand miles of wire, or instantly communicate through the air far beyond the reach of sight and sound? The success the student has achieved in pushing back the fringe of the great unknown, has enabled him the better to realize he is subject to a reign of law, and it has elevated his perception of the infinite and the sublime.

At the same time it is equally true that that opposition to movement of whatever sort or kind which, as already has been stated, seems an essential corollary to it, is apt to lead in us, as individuals, to pride in the dominant position we hold on earth, and leads us to forget we are but as flies on the wheel, chips on the torrent, or grains of sand in the whorl of the cyclone: even to proclaim "We and God," when a coupling with the beast of the field would be more in keeping with man's worldly relations.

There is also a growing belief among naturalists, who have closely observed wild life at home and free of fear, that what in man are called the finer feelings—friendship, affection and sympathy, are exhibited in a marked degree by creatures of more humble circles.

The student, moreover, has reason to suspect that as in the material world law and order reign, so also among the spiritual influences affecting free will, system prevails. Further than that, as there is to the individual a birth, maturity and death, and to communities a racial or national rise, a period of prosperity and ultimate decay, so does it appear in the non-material region of thought that a cycle holds good; that there have been to religions an inception, a zealous purpose, an acceptance, and then decline; also to ideas in other directions there comes the inspiration, the spread of waves of intelligence throughout communities in sympathy, and then a subsidence of the particular impulse, like as it is with epidemics of pestilence and accident.

Views of this sort are not entirely new; something of the kind was expressed by ancient writers, although it was left to modern times to more fully confirm the mastery of law and order, and the idea that activity meant the breaking away from harmonious quiescence. Later ideas have recognized a similarity of purpose in mundane interests which extends beyond a daily reawakening from unconsciousness to a state of bodily and mental activity with memory of previous periods of consciousness in the individual. It includes the replacement of units and the succession of dominant races. It goes even further and assumes the law of cycles to include in its grasp intangible impulses, the temperament of races, the family likeness and mental atavism; embraces the reincarnation of ancestral traits of body, finding a homologue in the reappearance of mental characteristics. These when purely animal and of the automaton order, we call intuition. They direct the infant to cry, the sheep to eat grass, the wolf to devour the sheep and the bird to build a nest and migrate. Nor is this intuitive impulse confined to the animal world, it is observable in the vegetable, in the shrinking from touch and consequent tired feeling of the sensitive plant, in the night-folding flower of the *Œnothera* and in the closing over on its victim of the *Drosera* leaf. Nor is it absent from the mineral world. Among growing crystals we detect it in the interlacing spicules of ice, in a network of cyanite where each crystal in its struggle to grow greater bends about to avoid its fellow crystal imbued with a similar purport. How these several attributes are maintained and stored in the germ, must remain forever a marvellous mystery, although constant repetition would indicate a governance by law.

Recognition has been made of the existence of influences, forces or impulses, which may, from the aspect of the individual organism, be malign. These the student contends are natural concomitants of life, for the interests of the unit necessarily become subordinate to the welfare of his community and his race in their competition and struggle for continuance on the face of the earth. We have to differentiate between Man, an order of beings, and 'man' an egotistical unit whose naturally selfish aspect is to regard the world as his oyster, and whose first instinct is self-preservation. Mal-

thusian views prevail. Utopia with perfect peace, continuous bliss, joy, and love for all, is necessarily an impossibility, and encouragement of any such idea a snare to the weak and emotional. The world cannot be otherwise than one of strife, both of brain and muscle, and the struggle must continue, of the weak with the strong and of the oppressed with the oppressor, however much we may disguise the unavoidable in euphonious terms.

While excess in all things is to be deprecated, and over-indulgence in speculations in matters of science is to be avoided, a generalization or two gives a fillip to enquiry and is helpful to the student. As a stimulus to observation it may for the moment be assumed there is no reason why the same systematic and orderly approach to the fields of the unknown, which method modern research inculcates, should not be adopted also to the realms of thought, nor why we should not assume that the energy of intelligence and the limitations to voluntary action may not also be under the dominion of law. If this be so, who shall say little is left in the field of science for the observer outside the walls of a college and a laboratory?

W. McKerron presented the treasurer's report, which having been audited and found correct, was received and adopted.

The report on the library was presented by H. Piers, showing that 2,330 books and pamphlets had been received by the Institute through its exchange-list during the calendar year 1904, anl 1,354 had been received during nine months of the piesent year (1905), viz., January to September. Increased use of the library was also reported as shown by the number of books borrowed during the year 1904, viz. 519, as against 296 in 1903. Particulars were also given of the total number of books and pamphlets received during the year 1904 by the Provincial Science Library with which the books of the Institute are incorporated. This number was 3,115, of which 2,330 were the society's exchanges as above-mentioned. The report was received and adopted.

The secretary reported that the Kings County Branch of the Institute had not met during this session of 1904-5.

W. McKERRON presented a report as delegate to the meeting of the Royal Society of Canada.

Votes of thanks were passed to HON. M. H. GOUDGE, President of the Legislative Council, for his courtesy in granting the society the use of the Council Chamber as a place of meeting during the past session; and to the SECRETARY OF THE SMITHSONIAN INSTITUTION, Washington, for courtesy in continuing to admit the Institute to the privileges of the Bureau of International Exchanges.

THE PRESIDENT brought to the notice of the meeting a note by R. RUEDEMANN, assistant state palæontologist, Albany, N. Y., on three specimens of *Dictyonema websteri* from New Canaan near Kentville, Kings Co., Nova Scotia, belonging to the Webster collection, Provincial Museum, Halifax. Mr. Ruedmann reports as follows regarding these specimens:

"*Dictyonema websteri* has been figured, but not described, by Dawson in Canadian Naturalist and Geologist, vol. v, 1860, p. 139, and again figured in Acadian Geology, 1891, p. 563, but not described. Thus this species is nowhere described. A careful comparison with authentical material of *D. retiforme,* Hall, from the Rochester (Niagaran) shale in New York, fails to show any differences sufficient for specific distinction, and it is, therefore, quite sure that *D. websteri* is identical with *D. retiforme.*" He reports further that a lot of *Dictyonemas* from Benton and Monument Settlement, Carleton County, New Brunswick, and from Navy Island, St. John, N. B., labelled *Dictyonema sociale,* all belong to one species, *Dictyonema flabelliforme,* Eichwald (sp.) (= *Dictyonema sociale,* Salter [sp.], a Latin name). This species is characteristic of the closing stage of the Cambric age.

The following were elected officers for the ensuing year (1905-1906):

President—F. W. W. DOANE, C. E., *ex-officio* F. R. M. S.

Vice-Presidents—PROFESSOR EBENEZER MACKAY, PH. D., and PROFESSOR J. EDMUND WOODMAN, D. SC.

Treasurer—WILLIAM MCKERRON.

Corresponding Secretary—A. H. MACKAY, LL. D., F. R. S. C.

Recording Secretary—HARRY PIERS.

Librarian—HARRY PIERS.

Councillors without Office—MAYNARD BOWMAN, B. A.; WATSON L. BISHOP; EDWIN GILPIN, JR., LL. D., F. R. S. C., I. S. O.; ALEXANDER MCKAY; J. B. MCCARTHY, B. A., M. SC.; PROFESSOR FREDERIC H. SEXTON, B. SC.; HENRY S. POOLE, D. SC., F. R. S. C.

Auditors—PROFESSOR D. A. MURRAY, PH. D.; R. MCCOLL, C. E.

A vote of thanks was presented to the retiring President, DR. POOLE, for the very able manner in which he had filled the position during his term of office.

A vote of thanks was presented to H. PIERS for his work as secretary.

FIRST ORDINARY MEETING.

Assembly Room, Province Building, Halifax, 13th Nov., 1905.

THE PRESIDENT, MR. DOANE, in the chair.

It was announced that the following had been elected ordinary members: A. A. HAYWARD, Halifax; ARTHUR STANLEY MACKENZIE, PH. D., Professor of Physics, Dalhousie College, Halifax; ERNEST BRYDON-JACK, M. A., C. E., professor of civil engineering, Dalhousie College, Halifax; and that MONRO ARCHIBALD, B. A., B. SC., had been elected an associate member.

CAPTAIN J. H. BARBOUR, M. D., Royal Army Medical Corps, Halifax, read a paper, "On the Flora of McNab's Island, Halifax Harbour, N. S." (See Transactions, p. 553). The subject was discussed by DR. A. H. MACKAY, and a vote of thanks presented to CAPTAIN BARBOUR.

In the absence of the author, H. PIERS read a "Catalogue of the Birds of Prince Edward Island," prepared by JOHN MACSWAIN, of Charlottetown. (See Transactions, p. 570).

Second Ordinary Meeting.

Assembly Room, Province Building, Halifax, 11th Dec., 1905.

The President, Mr. Doane, in the chair.

W. E. Lishman, M. A., M. I. M. E., of Durham, England, read a paper entitled, "Mining, Is it a Science?," in the course of which he said:

"It is safe to say that mining up to within recent years has stood in its own light. It has been regarded as essentially practical, the theoretical side of it being almost entirely ignored. It used to be a *sine qua non* for one holding an official position that he should be, to borrow an expression used in coal mining, "a good pitman." We will not quarrel with this, as it is very essential that a man who is to see to the actual working of a mine should be a really practical man, and so long as mining was carried on in a rule-of-thumb fashion and simply consisted in raising comparatively easily obtained and accessible minerals to the surface, such a man was the most suitable for the purpose. But now that in many countries the process of extracting and raising minerals, so far from being the simple affair it once was, has become one of the most complicated and far-reaching that man is called upon to perform, we may well question the policy of setting so much store by the purely practical man. And be it observed that it is just at the time when mining is making this marked advance forward, when, that is, methods are becoming more and more complicated, that scientific education on its part is making a like advance. The one is in fact complementary to the other. But such is the conservatism in human nature that in spite of the increasing complexity of mining operations on the one hand, and in spite of the impetus given to technical education on the other to meet this, yet those in authority are only now beginning to give up their predilections for the 'practical man' and to go in for one who by judicious training in practical and theoretical work should in all senses of the word prove more efficient for an official position than the former. It is for this reason that I say that mining has to a certain extent stood in its own light; but it is satisfactory to notice that a change is now taking place, as indeed it was bound to do, and the value of

the scientific man is becoming more and more recognized every day. This is still further emphasized in England by the recent parliamentary enactment providing that two years' study (with the necessary diploma) at an accredited college or institution, and three years' practical experience at a colliery, may take the place of the five years' practical work which previously constituted the qualification for sitting for the examination for colliery manager's certificate. In this connection, too, it may also be observed that the Durham College of Science, Newcastle, and other universities, have recently instituted degrees in mining, being I believe the first to adopt such a course. So that it is beginning to be recognized that mining should at least be regarded from a scientific stand-point. It remains for those interested in the subject to see that this stand-point is maintained, or if possible, improved upon. It is evident, too, that much more will be expected of the future mining engineer than has been the case in the past. And necessarily so, for as the more accessible and more easily worked seams and veins are approaching exhaustion, the need for more scientific and ingenious methods of reaching those less accessible will become more pressing, and will demand all the resources we are capable of rendering."

The subject was discussed by Dr. A. H. MacKay, Professor Sexton and Dr. Woodman, and a vote of thanks was presented to the lecturer.

Dr. A. H. MacKay read a paper entitled, "Fungi of Nova Scotia; first supplementary list," (see Transactions, vol. xii, pt. 1, p. 119), which was discussed by Dr. H. H. Read, Dr. E. MacKay, Dr. A. P. Reid, W. L. Bishop and H. Piers.

Third Ordinary Meeting.

Assembly Room, Province Building, Halifax, 12th Feb., 1906.

The President, Mr. Doane, in the chair.

H. W. Johnston, C. E., assistant city engineer, Halifax, read a paper on the "Halifax Water Works." (See Transactions, vol. xii, pt. 1, p. 72). The subject was discussed by the President, Professor Jack, W. L. Bishop, Dr. A. H. MacKay, T. V. Hill, and Dr. E. MacKay; and a vote of thanks was presented to the lecturer.

FOURTH ORDINARY MEETING.

City Council Chamber, Halifax, 12th March, 1906.

THE PRESIDENT, MR. DOANE, in the chair.

In the absence of the author, DR. POOLE read a paper by R. W. ELLS, LL. D., F. R. S. C., of the Geological Survey of Canada, on "The Oil-fields of Eastern Canada." (See Transactions, p. 598). Specimens illustrating the paper were shown from the collection of DR. POOLE. The paper was discussed by the PRESIDENT, and DRS. WOODMAN and POOLE.

FIFTH ORDINARY MEETING.

City Council Chamber, Halifax, 9th April, 1906.

THE PRESIDENT, MR. DOANE, in the chair.

DR. POOLE read a letter received by the curator of the Provincial Museum, from LAURENCE M. LAMBE, of the Geological Survey of Canada, relative to amphibian-like remains found by Dr. Poole at the Joggins, Cumberland Co., N. S., and now in the Provincial Museum. The specimen, Mr. Lambe states, does not supply the information necessary for its determination.

DR. POOLE took the chair, while the PRESIDENT read a paper on "The Frost and Drought of 1905." (See Transactions, p. 623).

It was resolved that the question as to the desirability of having a self-recording rain-gauge placed by the meteorological department at Halifax, be referred to the council to take action if it sees fit.

WATSON L. BISHOP, superintendent of water works, Dartmouth, read a paper on "Eels in Water Pipes and Their Migration." (See Transactions, p. 640). The subject was discussed by the PRESIDENT, DR. A. H. MACKAY, R. H. BROWN and H. PIERS.

DR. A. H. MACKAY communicated a paper by FRANK H. REID, entitled, "Notes on Protective Colouring," which was discussed by DR. MACKAY, W. L. BISHOP and H. PIERS; and a vote of thanks was presented to MR. REID.

The following papers were read by title: "The Grignard Synthesis: Action of Phenyl Magnesium Bromide on Camphor," by H. JERMAIN M. CREIGHTON, Dartmouth, (see Transactions, p. 593); and "Contributions to the Study of Hydroxylamine," by G. M. JOHNSTONE MACKAY, B. A., Dartmouth, (see Transactions, vol. xi, pt. 2, p. 324).

SIXTH ORDINARY MEETING.

Room of Mining Society of N. S., Halifax, 21st May, 1906.

THE PRESIDENT, MR. DOANE, in the chair.

WATSON L. BISHOP, Dartmouth, brought to the notice of the Institute the occurrence of Star-nosed Moles (*C. cristata*) and a shrew in a submerged eel trap at the Dartmouth water-supply lake.

In the absence of the author, H. W. JOHNSTON read a paper by W. G. YORSTON, C. E., city engineer of Sydney, C. B., on "Water Powers of the Mersey River, Nova Scotia." (See Transactions, p. 651). The paper was discussed by the PRESIDENT, R. McCOLL, A. A. HAYWARD, W. L. BISHOP, DR. H. H. READ, and DR. A. H. MACKAY.

RODERICK McCOLL, C. E., provincial engineer, Halifax, presented a paper "On the Damage Done to Timber by *Toredo navalis* and *Limnoria lignorum*." The subject was discussed by the PRESIDENT, DR. A. H. MACKAY, W. L. BISHOP, and H. PIERS.

A. H. MACKAY, LL. D., F. R. S. C., superintendent of education, Halifax, presented a paper entitled, "Phenological Observations, Canada, 1905"; and also a paper on "Water-rolled Weed-balls." (See Transactions, p. 667).

A vote of thanks was passed to PRESIDENT HAYWARD and the Mining Society of Nova Scotia for their courtesy in permitting the use of their room as a place of meeting.

HARRY PIERS,
Recording Secretary.

APPENDIX I.

LIST OF MEMBERS, 1902-03.

ORDINARY MEMBERS.

	Date of Admission.
Allison, Augustus, Halifax	Feb. 15, 1869
Bayer, Rufus, Halifax	March 4, 1890
Bishop, Watson L., Dartmouth, N. S	Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax	March 13, 1884
Brown, Richard H., Halifax	Feb. 2, 1903
Brown, R. Balfour, Yarmouth, N. S	Jan. 10, 1891
*Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax	Feb. 2, 1903
Cowie, Andrew J., M. D., L. R. C. P. E., Halifax	Jan. 27, 1893
Davis, Charles Henry, C. E., New York City, U. S. A	Dec. 5, 1900
Dixon, Prof. Stephen Mitchell, B. A., B. A. I., Dalhousie College, Halifax	April 8, 1902
Doane, F. W. W., City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Sydney, C. B	Nov. 30, 1892
Egan, Thomos J., Halifax	Jan. 6, 1890
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
Finn, Wm. D., M. D., Halifax	Oct. 29, 1894
*Forbes, John, Halifax	March 14, 1883
*Fraser, C. Frederick, Principal, School for the Blind, Halifax	March 31, 1890
Gates, Herbert E., Architect, Halifax	April 17, 1899
*Gilpin, Edwin, M. A., LL. D., F. R. S. C., Inspector of Mines, Halifax	April 11, 1873
Hattie, William Harrop, M. D., Dartmouth	Nov. 12, 1892
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Jacques, Hartley S., M. D., Halifax	May 8, 1894
Jenney, John J., Halifax	March 3, 1903
Johnston, Harry W., C. E., Halifax	Dec. 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
McCarthy, J. B., B. A., B. SC., teacher of Science, County Academy, Halifax	Dec. 4, 1901
McColl, Roderick, C. E., Assistant Provl. Engineer, Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
*MacGregor, Prof. J. G., M. A., D. Sc., F. R. S., F. R. S. C., Edinburgh University, Edinburgh	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, A. H., B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
McKerron, William, Halifax	Nov. 30, 1891

*Life Members.

Date of Admission

Marshall, Gilford R., Principal, Richmond School, Halifax ....April 4, 1894
Morton, S. A., M. A., County Academy, Halifax ....Jan. 27, 1893
Murphy, Martin, C. E., D. SC., Provincial Engineer, Halifax...............Jan. 15, 1870
Newman, C. L., Dartmouth, N. S.......................................Jan. 27, 1893
O'Hearn, Peter, Principal, St. Patrick's Boys' School, Halifax............Jan. 16, 1890
*Parker, Hon. Daniel McN., M. D., M. L. C., Dartmouth, N. S... 1871
Pearson, B. F., Barrister, Halifax ....March 31, 1890
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax ....Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC. R. S. M., F. G. S., F. R. S. C., M. CAN. SOC. C. E., HON. MEM. INST. M. E., Halifax.................. Nov. 11, 1872
Read. Herbert H., M. D., L. R. C. S., Halifax ....Nov. 27, 1889
*Robb, D. W., Amherst, N. S...March 4, 1890
Rutherford, John, M. E., Windsor, N. S...............................Jan. 8, 1865
*Smith, Prof. H. W., B. SC., Agricultural School, Truro, N. S.; Assoc Memb., Jan. 6, 1890..Dec. 1900
*Stewart, John, M. B. C. M., Halifax...................................Jan. 12, 1885
Weatherbe, Hon. Mr. Justice, Halifax..................................March 28, 1895
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S....Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax ....May 3, 1889
Woodman. Prof. J. Edmund, M. A., D. SC., School of Mining and Metallurgy, Dalhousie College, Halifax ....Dec. 3, 1902
Yorston, W. G., C. E., Sydney, C. B ....Nov. 12, 1892

ASSOCIATE MEMBERS.

*Caie, Robert, Yarmouth, N. S...Jan, 31, 1890
*Dickenson, S. S., Superintendent, Commercial Cable Co., Hazelhill, Guysborough Co., N. S ....March 4, 1895
Edwards, Arthur M., M. D., F. L. S., Newark, N. J.......................Dec. 12, 1898
Gates, Reginald R., Mt. Allison University, Sackville, N. B...............Feb. 2, 1903
Haley, Prof. Frank R., Acadia College, Wolfville, N. S...................Nov. 5, 1901
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S ....May 17, 1899
Hunton, Prof. S. W., M. A., Mount Allison College, Sackville, N. B.......Jan. 6, 1890
Jaggar, Miss A. Louise, Cambridge, Mass.................................Dec. 5, 1900
James, C. C., M. A., Depy. Min. of Agriculture, Toronto, Ontario..........Dec. 3, 1896
Jennison, W. F., Sydney, C. B. ....May 5, 1903
*Johns, Thomas W., Yarmouth, N. S ....Nov. 27, 1889
*Keating, E. H., C. E., Toronto Ry. Co., Toronto, Ont.; Ord. Memb., April 12, 1882..April 11, 1900
*Kennedy, Prof. Geo. T., M. A., D. SC., F. G. S., King's College, Windsor, N. S ....Nov. 9, 1882
Lawrence, H., D. D. S., Wolfville, N. S ....March 9, 1903
MacIntosh, Kenneth, St. George's Channel, C. B; Ord. Memb., Jan. 4, 1892.. June, 1900
*MacKay, Hector H., M. D., New Glasgow, N. S........................Feb. 4, 1902
McKenzie, W. B., C. E., Moncton, N. B................................March 31, 1882
McLeod, R. R., Brookfield, N. S ....Dec. 3, 1897
Magee, W. H., PH. D., High School, Parrsboro', N. S....................Nov. 29, 1894
Matheson, W. G., New Glasgow, N. S ....Jan. 31, 1890
Payzant, E. N., M. D., Wolfville, N. S ....April 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S.................................Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis Co., N. S.........Jan. 31, 1890
*Robinson, C. B., B. A., Pictou Academy, Pictou, N. S...................Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S...................Nov. 29, 1894

*Life Members.

Date of Admission.

Russell, Prof. Lee, B. S., Worcester, Mass..Dec. 3, 1896
Sawyer, Prof. Everett W., Acadia College, Wolfville, N. S.....................Feb. 6, 1901
Sears, Prof. F. C., Director N. S. School of Horticulture, Wolfville, N. S. Feb. 6, 1901

CORRESPONDING MEMBERS.

Ami, Henry M., D. SC. F. G. S., F. R. S. C., Geological Survey, Ottawa, Ontario..Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. S. C., University of New Brunswick, Fredericton, N. B..Jan. 6, 1890
Ball, Rev. E. H., Westville, N. S..Nov. 29, 1871
Bethune, Rev. C. J. S., M. A., D. C. L., F. R. C. S., London, Ontario..........Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Chatham, N. B......................................Dec. 3, 1902
Davidson, Prof. John, PHIL. D., Univ. of N. B., Fredericton, N. B ....Dec. 12, 1898
Dobie, W. Henry, M. D., Chester, England......................................Dec. 3, 1897
Duns, Prof. John, New College, Edinburgh, Scotland.........................Dec. 30, 1887
Ells, R. W. LL. D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont. .Jan. 2. 1894
Fairbault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa; Assoc. Memb., March 6, 1888...................................Dec. 3, 1902
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario ....March 3, 1891
Fletcher, James, LL. D., F. L. S , F. R. S. C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ontario......................................March 2, 1897
Ganong, Prof. W. F., B. A., PH D., Smith College, Northampton, Mass., U. S. A..Jan. 6, 1890
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa ......May 5, 1896
Hay, George U., D. SC., F. R. S. C., St. John, N. B ....Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia ....May 5, 1892
McClintock, Vice-Admiral Sir Leopold. Kt., F. R. S ....June 10, 1880
McSwain, John, Charlottetown, P. E. I ....Dec. 3, 1902
Matthew, G. F., M. A., D. SC., F. R. S. C., St. John, N. B ....Jan. 6. 1890
Maury, Rev. Mytton, D. D., Ithaca, N Y., U. S. A ....Nov. 30, 1891
Peter, Rev. Brother Junian, St. Joseph's Commercial College, Detroit, U. S A..Dec. 12. 1898
Pickford, Charles, Halifax ....Mar 2, 1900
Prest, Walter H., M. E., Bedford ; Assoc. Memb., Nov. 29 1894 ....Nov. 2, 1900
Prichard, Arthur H. Cooper, Museum of Brooklyn Inst. of Arts and Sciences, Brooklyn, N. Y...Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario ....Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A ....March 31, 1890
Spencer, Prof. J. W., PH. D., F. G. S., Washington, D. C., U. S. A............Jan. 31, 1890
Weston, Thomas C., F. G. S. A., Ottawa, Ontario................................May 12, 1877

APPENDIX II.

LIST OF MEMBERS, 1903-04.

ORDINARY MEMBERS.

	Date of Admission.
Bayer, Rufus, Halifax	March 4, 1890
Bishop, Watson L., Supt of Water Works, Dartmouth, N. S	Jan. 6, 1890
Bowman, Maynard, B. A, Public Analyst, Halifax	March 13, 1884
Brown, Richard H., Halifax	Feb. 2, 1903
Brown, R. Balfour, Yarmouth, N. S	Jan. 10, 1891
Budge, D., General Supt. Halifax & Bermuda Cable Co., Halifax	Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax	Feb. 2, 1903
*Davis, Charles Henry, C. E., New York City, U. S. A	Dec. 5, 1900
Dixon, Prof. Stephen Mitchell, B. A., B. A. I., Dalhousie College, Halifax	April 8, 1902
Doane, F. W. W., City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Glace Bay, C. B.	Nov. 30, 1892
Egan, Thomas J., Halifax	Jan. 6, 1890
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1891
*Forbes, John, Moncton, N. B.	March 14, 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax	March 31, 1890
Gates, Herbert E., Architect, Halifax	April 17, 1899
*Gilpin, Edwin, M. A., LL. D., F. R. S. C, Inspector of Mines, Halifax	April 11, 1873
Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth	Nov. 12, 1892
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Jacques, Hartley S., M. D, Halifax	May 8, 1891
Johnston, Harry W., C. E., Halifax	Dec 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
McCarthy, J. B., B. A., B. SC., teacher of science, County Academy, Halifax	Dec. 4, 1901
McColl, Roderick, C. E., Provl. Engineer, Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
*MacGregor, Prof. J. G., M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, A. H., B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
MacKay, George M Johnstone, Dartmouth, N. S	Dec. 18, 1903
McKerron, William, Halifax	Nov. 30, 1891

*Life Members.

	Date of Admission.
Marshall, Gilford R., Principal, Richmond School, Halifax	April 4, 1894
Morton, S. A., M. A., County Academy, Halifax	Jan. 27, 1893
Murphy, Martin, C. E., D. SC., I. S. O., Halifax	Jan. 15, 1870
Murray, Prof. Daniel Alexander, Ph. D., Dalhousie College, Halifax	Dec. 18, 1903
Newman, C. L., Dartmouth, N. S	Jan. 27, 1893
O'Hearn, Peter, Principal, St. Patrick's Boys' School, Halifax	Jan. 16, 1890
*Parker, Hon. Daniel McN., M. D., Dartmouth, N. S	1871
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax	Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC. R. S. M., F. G. S., F. R. S. C., M. CAN. SOC. C. E., HON. MEM. INST. M. E., Halifax	Nov. 11, 1872
Read, Herbert H., M. D., L. R. C. S., Halifax	Nov. 27, 1889
*Robb, D. W., Amherst, N. S	March 4, 1890
Rutherford, John, M. E., Halifax	Jan. 8, 1865
Sexton, Prof. Frederic H., Dalhousie College, Halifax	Dec. 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural School, Truro, N. S.; Assoc-Memb., Jan. 6, 1890	Dec. 1900
*Stewart, John, M. B. C. M., Halifax	Jan. 12, 1885
Weatherbe, Hon. Mr. Justice, Halifax	March 28, 1895
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S	Nov. 29, 1894
Wilson Robert J., Secretary, School Board, Halifax	May 3, 1889
Winfield, James H., Manager, N. S. Telephone Co., alifax	Dec. 18, 1903
Woodman, Prof. J. Edmund, M. A., D. SC., School of Mining and Metallurgy, Dalhousie College, Halifax	Dec. 3, 1902
*Yorston, W. G., C. E., Sydney, C. B	Nov. 12, 1892

ASSOCIATE MEMBERS.

*Caie, Robert, Yarmouth. N. S	Jan, 31, 1890
*Dickenson, S. S., Commercial Cable Co., New York, U. S. A	March 4, 1895
Edwards, Arthur M., M. D., F. L. S., Newark, N J	Dec. 12, 1898
Gates, Reginald R, Mt. Allison University, Sackville, . B	Feb. 2, 1903
Haley, Prof. Frank R., Acadia College, Wolfville, N. S	Nov. 5, 1901
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S	May 17, 1899
Hunton, Prof. S. W., M. A., Mount Allison College, Sackville, N. B	Jan. 6, 1890
Jaggar, Miss A Louise, Cambridge, Mass	Dec. 5, 1900
James, C. C., M. A., Depy. Min. of Agriculture, Toronto, Ontario	Dec. 3, 1896
Jennison, W. F., Sydney, C. B.	May 5, 1903
*Johns, Thomas W., Yarmouth, N. S	Nov. 27, 1889
*Keating, E. H., C. E., Toronto Ry. Co., Toronto, Ont.; Ord. Memb., April 12, 1882	April 11, 1900
*Kennedy, Prof. Geo. T., M. A., D. SC., F. G. S., Wolfville, N. S	Nov. 9, 1882
Lawrence, H., D. D. S., Wolfville, N. S	March 9, 1903
MacIntosh, Kenneth, St. George's Channel, C. B; Ord. Memb., Jan. 4, 1892	June, 1900
*MacKay, Hector H., M. D., New Glasgow, N. S	Feb. 4, 1902
McKenzie, W. B., C. E., Moncton, N. B	March 31, 1882
McLeod, R. R, Brookfield, N. S	Dec. 3, 1897
Magee, W. H., PH. D., High School, Parrsboro', N. S	Nov. 29, 1894
Matheson, W. G., New Glasgow, N. S	Jan. 31, 1890
Payzant, E. N., M. D., Wolfville, N. S	April 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S	Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton. Annapolis Co., N. S	Jan. 31, 1890

*Life Members.

Date of Admission.

*Robinson, C. B., B. A., New York Botanical Garden, New York, U. S. A. Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S. ..Nov. 29, 1894
Russell, Prof. Lee, B. S., Worcester, Mass ... Dec. 3, 1896
Sawyer, Prof. Everett W., Acadia College, Wolfville, N. S. ... Feb. 6, 1901
Sears, Prof. F. C., Director N. S. School of Horticulture, Wolfville, N. S. Feb. 6, 1901

CORRESPONDING MEMBERS.

Ami, Henry M., D. SC., F. G. S., F R. S. C., Geological Survey, Ottawa, Ontario ... Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D.. F. R. S. C., University of New Brunswick, Fredericton, N. B ... Jan. 6, 1890
Ball, Rev. E. H., Barrington, N. S. ... Nov. 29, 1871
Bethune, Rev. C. J. S., M. A., D. C. L., F. R. C. S., London, Ontario ... Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Chatham, N. B ... Dec. 3, 1902
Davidson, Prof. John, PHIL. D ... Dec. 12, 1898
Dobie, W. Henry, M. D., Chester, England ... Dec. 3, 1897
Duns, Prof. John, New College, Edinburgh, Scotland ... Dec. 30, 1887
Ells, R. W., LL. D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont.. Jan. 2, 1894
Faribault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa ; Assoc. Memb , March 6, 1888 ... Dec. 3, 1902
Fletcher, Hugh, B. A , Geological Survey, Ottawa, Ontario ... March 3, 1891
Fletcher, James, LL. D., F. L. S , F. R. S. C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ontario ... March 2, 1897
Ganong, Prof. W. F., B. A., PH D., Smith College, Northampton, Mass., U. S. A ... Jan. 6, 1890
Hardy, Maj.-General Campbell, Dover, England ... Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa ... May 5, 1896
Hay, George U., D. SC , F. R. S C., St. John, N. B ... Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia ... May 5, 1892
McClintock, Vice-Admiral Sir Leopold, Kt., F. R. S ... June 10, 1880
McSwain, John, Charlottetown, P. E. I ... Dec. 3, 1902
Matthew, G. F., M. A., D. SC., F. R. S. C., St. John, N. B ... Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A ... Nov. 30, 1891
Peter, Rev. Brother Junian, Fall River, Mass., U. S. A ... Dec. 12, 1898
Pickford, Charles, Halifax ... March 2, 1900
Prest, Walter Henry, M. E., Bedford ; Assoc. Memb., Nov. 29 1894 ... Nov. 2, 1900
Prichard, Arthur H. Cooper, Collegiate School, Windsor, N. S. ... Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario ... Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A ... Mar. 31, 1890
Weston, Thomas C., F. G. S. A., Ottawa, Ontario ... May 12, 1877

* Life Members.

APPENDIX III.

LIST OF MEMBERS, 1904-05.

ORDINARY MEMBERS.

	Date of Admission.
Bayer, Rufus, Halifax	March 4, 1890
Bishop Watson L., Supt of Water Works, Dartmouth, N. S.	Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax	March 13, 1884
Brown, Richard H., Halifax	Feb. 2, 1903
Brown, R. Balfour, Saulnierville, N. S.	Jan. 10, 1891
Budge, D., General Supt. Halifax & Bermuda Cable Co., Halifax	Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax	Feb. 2, 1903
*Davis, Charles Henry, C. E., New York City, U. S. A	Dec. 5, 1900
Dixon, Prof. Stephen Mitchell, B. A., B. A. I., University of Birmingham, Birmingham, England	April 8, 1902
Doane, F. W. W., City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Glace Bay, C. B.	Nov. 30. 1892
Egan, Thomas J., Halifax	Jan. 6. 1890
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
*Forbes, John, Moncton, N. B.	March 14. 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax	March 31 1890
Gates, Herbert E., Architect, Halifax	April 17, 1899
*Gilpin, Edwin, M.A., LL.D., F.R.S.C., I.S.O., Inspector of Mines, Halifax	April 11, 1873
Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth	Nov. 12, 1892
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Johnston, Harry W., C. E., Asst City Engineer, Halifax	Dec. 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
McCarthy, J. B., B. A., M. SC., teacher of science, County Academy, Halifax	Dec. 4, 1901
McColl, Roderick, C. E., Provl. Engineer, Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
*MacGregor, Prof. J. G., M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh, Scotland	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, A. H., B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
*MacKay, George M. Johnstone, Dartmouth, N. S	Dec. 18, 1903
McKerron, William, Halifax	Nov. 30, 1891

*Life Members.

Date of Admission.

Marshall, Gilford R., Principal, Compton Avenue School, Halifax .....April 4, 1894
Morton, S. A., M. A., County Academy, Halifax ....Jan. 27, 1893
Murphy, Martin, C. E., D. SC., I. S. O., Saskatoon, Sask ....Jan. 15, 1870
Murray, Prof. Daniel Alexander, Ph. D., Dalhousie College, Halifax ....Dec. 18, 1903
*Parker, Hon. Daniel McN., M. D., Dartmouth, N. S....................... 1871
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax ....Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC. R. S M, F. G. S, F. R. S. C, M. CAN. SOC. C. E., HON. MEM. INST. M. E., Halifax ....Nov. 11, 1872
Read, Herbert H., M. D., L. R. C. S., Halifax ....Nov. 27, 1889
*Robb, D. W., Amherst, N. S ....March 4, 1890
Rutherford, John, M. E., Halifax ....Jan. 8, 1865
Sexton, Prof. Frederic H., Dalhousie College, Halifax ....Dec. 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural School, Truro, N. S.; Assoc. Memb., Jan. 6, 1890 ....Dec. 1900
*Stewart, John, M. B. C. M., Halifax ....Jan. 12, 1885
Tinling, Captain E. B., R. N., Marine & Fisheries Dept., Halifax ......Feb. 7, 1905
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S....Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax ....May 3, 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax..............Dec. 18, 1903
Woodman, Prof J. Edmund, M. A, D. SC., School of Mining and Metallurgy, Dalhousie College, Halifax ....Dec. 3, 1902
*Yorston, W. G., C.E., City Engineer, Sydney, C. B ....Nov. 12, 1892

ASSOCIATE MEMBERS.

*Caie, Robert, Yarmouth, N. S ....Jan. 31, 1890
*Dickenson, S. S., Commercial Cable Co., New York, U. S. A............March 4, 1895
Edwards, Arthur M., M. D., F. L. S, Newark, N. J ....Dec. 12, 1898
Gates, Reginald R., Mt. Allison University, Sackville, N. B ....Feb. 2, 1903
Haley, Prof. Frank R, Acadia College, Wolfville, N. S ....Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S ....March 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S ....May 17, 1899
Hunton, Prof. S. W, M. A. Mount Allison College, Sackville, N. B ....Jan. 6, 1890
Jaggar, Miss A. Louise, Cambridge, Mass ....Dec. 5, 1900
James, C. C., M. A., Depy. Min. of Agriculture, Toronto, Ontario ....Dec. 3, 1896
Jennison, W. F., Sydney, C. B ....May 5, 1903
*Johns, Thomas W., Yarmouth, N. S ....Nov. 27, 1889
*Keating, E. H., C. E., Toronto, Ry. Co., Toronto, Ont.; Ord. Memb. April 12, 1882 ....April 11, 1900
*Kennedy, Prof. Geo. T., M. A., D. SC. F. G. S., Wolfville, N. S ....Nov. 9, 1882
Lawrence, H., D. D. S., Wolfville, N. S ....March 9, 1903
McIntosh, Kenneth, St. George's Channel, C. B.; Ord. Memb., Jan. 4, 1892 ....June 1900
*MacKay, Hector H., M. D., New Glasgow, N. S ....Feb. 4, 1902
McKenzie, W. B., C. E., Moncton, N. B ....March 31, 1882
McLeod, R. R., Brookfield, N. S ....Dec. 3, 1897
Magee, W. H., PH. D., Annapolis, N. S ....Nov. 29, 1894
Matheson, W. G., New Glasgow, N. S ....Jan. 31, 1890
Payzant, E N., M. D., Wolfville, N. S ....April 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S.......................................Nov. 5, 1901
*Reid, A. P., M. D., L. R. C. S., Middleton, Annapolis Co., N. S............Jan. 31, 1890
*Robinson, C. B., B.A., New York Botanical Garden, New York, U. S. A.Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S....................Nov. 29, 1894

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*Life Members.

Date of Admission.

Russell, Prof. Lee, B. S., Worcester, Mass.......................................Dec. 3, 1896
Sawyer, Prof. Everett W., Acadia College, Wolfville, N. S.................Feb. 6, 1901
Sears, Prof. F. C., Director N. S. School of Horticulture, Wolfville, N. S. Feb. 6, 1901

CORRESPONDING MEMBERS.

Ami, Henry M., D. SC., F. G. S., F R. S. C., Geological Survey, Ottawa, Ontario.......................................Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. S. C., University of New Brunswick, Fredericton, N. B.......................................Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S.......................................Nov. 29, 1871
Bethune, Rev. Charles J. S. M. A., D. C. L., F. R C. S., Ontario Agricultural College, Guelph, Ont.......................................Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Chatham, N. B.......................................Dec. 3, 1902
Davidson, Prof. John, PHIL. D.......................................Dec. 12, 1898
Dobie, W. Henry, M. D., Chester, England.......................................Dec. 3, 1897
Ells, R. W., LL. D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont..Jan. 2, 1891
Faribault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa; Assoc. Memb., March 6, 1888.......................................Dec. 3, 1902
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario.......................................March 3, 1891
Fletcher, James, LL. D., F. L. S, F. R. S. C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ontario.......................................March 2, 1897
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass., U. S. A.......................................Jan. 6, 1890
Hardy, Maj.-General Campbell, R. A., Dover, England.......................................Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa.......................................May 5, 1896
Hay, George U., D. SC., F. R. S. C., St. John, N. B.......................................Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia.......................................May 5, 1892
McClintock, Vice-Admiral Sir Leopold, Kt., F. R.S., London, Eng.......................................June 10, 1880
McSwain, John, Charlottetown, P. E. I.......................................Dec. 3, 1902
Matthew, G. F., M. A., D. SC., F. R. S. C., St. John, N. B.......................................Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A.......................................Nov. 30, 1891
Peter, Rev. Brother Junian, Fall River, Mass., U. S. A.......................................Dec. 12, 1898
Pickford, Charles, Halifax.......................................March 2, 1900
Prest, Walter Henry, M. E., Bedford; Assoc. Memb., Nov. 29, 1891.......................................Nov. 2, 1900
Prichard, Arthur H. Cooper, Boston, Mass.......................................Dec. 4, 1901
Prince. Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario.......................................Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A.......................................Mar. 31, 1890
Weston, Thomas C., F. G. S. A., Ottawa, Ontario.......................................May 12, 1877

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* Life Members.

APPENDIX IV.

LIST OF MEMBERS, 1905-06.

ORDINARY MEMBERS.

	Date of Admission.
Bayer, Rufus, Halifax	March 4, 1890
Bishop, Watson L., Supt. of Water Works, Dartmouth, N. S.	Jan. 6, 1890
Bowman, Maynard, B. A., Public Analyst, Halifax	March 13, 1884
Brown, Richard H., Halifax	Feb. 2, 1903
Budge, Daniel, General Supt. Halifax & Bermuda Cable Co., Halifax	Oct. 30, 1903
*Campbell, Donald A., M. D., Halifax	Jan. 31, 1890
Campbell, George Murray, M. D., Halifax	Nov. 10, 1884
Colpitt, Parker R., City Electrician, Halifax	Feb. 2, 1903
*Davis, Charles Henry, C. E., New York City, U. S. A	Dec. 5, 1900
Dixon, Prof. Stephen Mitchell, B. A., B. A. I., University of Birmingham, Birmingham, England	April 8, 1902
Doane, Francis William Whitney, City Engineer, Halifax	Nov. 3, 1886
Donkin, Hiram, C. E., Glace Bay, C. B.	Nov. 30, 1892
Egan, Thomas J., Halifax	Jan. 6, 1890
Fearon, James, Principal, Deaf and Dumb Institution, Halifax	May 8, 1894
*Forbes, John, Moncton, N. B.	March 14, 1883
*Fraser, C. Frederick, LL. D., Principal, School for the Blind, Halifax	March 31 1890
Gates, Herbert E., Architect, Halifax	April 17, 1899
*Gilpin, Edwin, M.A., LL.D., F.R.S.C., I.S.O., Inspector of Mines, Halifax	April 11, 1873
Hattie, William Harrop, M. D., Supt. N. S. Hospital, Dartmouth	Nov. 12, 1892
Hayward, A. A., Halifax	Nov. 7, 1905
Irving, G. W. T., Education Dept., Halifax	Jan. 4, 1892
Jack, Prof. Ernest Brydone, M. A., C. E., Dalhousie College, Halifax	Nov. 7, 1905
Johnston, Harry W., C. E., Asst. City Engineer, Halifax	Dec. 31, 1894
*Laing, Rev. Robert, Halifax	Jan. 11, 1885
McCarthy, J. B., B. A., M. SC., teacher of science, County Academy, Halifax	Dec. 4, 1901
McColl, Roderick, C. E., Provl. Engineer, Halifax	Jan. 4, 1892
Macdonald, Simon D., F. G. S., Halifax	March 14, 1881
*MacGregor, Prof. James Gordon, M. A., D. SC., F. R. S., F. R. S. C., Edinburgh University, Edinburgh, Scotland	Jan. 11, 1877
McInnes, Hector, LL. B., Halifax	Nov. 27, 1889
*McKay, Alexander, Supervisor of Schools, Halifax	Feb. 5, 1872
*MacKay, Alexander Hector, B. A., B. SC., LL. D., F. R. S. C., Superintendent of Education, Halifax	Oct. 11, 1885
MacKay, Prof. Ebenezer, PH. D., Dalhousie College, Halifax	Nov. 27, 1889
*MacKay, George M. Johnstone, Dartmouth, N. S	Dec. 18, 1903
MacKenzie, Prof. Arthur Stanley, Ph. D., Dalhousie College, Halifax	Nov. 7, 1905
McKerron William, Halifax	Nov. 30, 1891

*Life Members.

Date of Admission.

Marshall, Gilford R., Principal, Compton Avenue School, Halifax .... April 4, 1894
Morton, S. A., M. A., County Academy, Halifax .... Jan. 27, 1893
Murphy, Martin, C. E., D. SC., I. S. O., Saskatoon, Sask .... Jan. 15, 1870
Murray, Prof. Daniel Alexander, Ph. D., Dalhousie College, Halifax .... Dec. 18, 1903
*Parker, Hon. Daniel McN., M. D., Dartmouth, N. S...................... 1871
Piers, Harry, Curator Provincial Museum and Librarian Provincial Science Library, Halifax .... Nov. 2, 1888
*Poole, Henry Skeffington, A. M., ASSOC. R. S M, F. G. S, F. R. S. C, M. CAN. SOC. C. E., HON. MEM. INST. M. E., Halifax .... Nov. 11, 1872
Read, Herbert H., M. D., L. R. C. S., Halifax .... Nov. 27, 1889
*Robb, D. W., Amherst, N. S .... March 4, 1890
Rutherford, John, M. E., Halifax .... Jan. 8, 1865
Sexton, Prof. Frederic H. Dalhousie College, Halifax .... Dec. 18, 1903
*Smith, Prof. H. W., B. SC., Agricultural School, Truro, N. S.; Assoc. Memb., Jan. 6, 1890 .... Dec. 1900
*Stewart, John, M. B. C. M., Halifax .... Jan. 12, 1885
Tinling, Captain E. B., R. N., Marine & Fisheries Dept., Halifax ...... Feb. 7, 1905
Wheaton, L. H., Chief Engineer, Coast Railway Co., Yarmouth, N. S .... Nov. 29, 1894
Wilson, Robert J., Secretary, School Board, Halifax .... May 3, 1889
Winfield, James H., Manager, N. S. Telephone Co., Halifax .... Dec. 18, 1903
Woodman, Prof J. Edmund, M. A., D. SC., School of Mining and Metallurgy, Dalhousie College, Halifax .... Dec. 3, 1902
*Yorston, W. G., C.E., City Engineer, Sydney, C. B .... Nov. 12, 1892

ASSOCIATE MEMBERS.

Archibald, Monro. B. A., B Sc, Truro, N. S. .... Nov. 7, 1905
*Caie, Robert, Yarmouth, N. S .... Jan. 31, 1890
*Dickenson, S. S., Commercial Cable Co., New York, U. S. A .... March 4, 1895
Edwards, Arthur M., M. D., F. L. S, Newark, N. J .... Dec. 12, 1898
Gates, Reginald R., Mt. Allison University, Sackville, N. B .... Feb. 2, 1903
Haley, Prof. Frank R, Acadia College, Wolfville, N. S .... Nov. 5, 1901
Harlow, L. C., B. SC., Prov. Normal School, Truro, N. S .... March 23, 1905
Haycock, Prof. Ernest, Acadia College, Wolfville, N. S .... May 17, 1899
Hunton, Prof. S. W, M. A. Mount Allison College, Sackville, N. B .... Jan. 6, 1890
Jaggar, Miss A Louise, Cambridge, Mass .... Dec. 5, 1900
James, C. C., M. A., Depy. Min. of Agriculture, Toronto, Ontario .... Dec. 3, 1896
Jennison, W. F., Sydney, C. B .... May 5, 1903
*Johns, Thomas W., Yarmouth, N. S .... Nov. 27, 1889
*Keating, E. H., C. E., Toronto, Ry. Co, Toronto, Ont.; Ord. Memb. April 12, 1882 .... April 11, 1900
*Kennedy, Prof. Geo. T., M. A., D. SC. F. G. S., Wolfville, N. S .... Nov. 9, 1882
Lawrence, H., D. D. S., Wolfville, N. S .... March 9, 1903
McIntosh, Kenneth, St Peters, C. B.; Ord. Memb, Jan. 1, 1892 .... June 1900
*MacKay, Hector H., M. D., New Glasgow, N. S .... Feb. 4, 1902
McKenzie, W. B., C. E., Moncton, N. B .... March 31, 1882
McLeod, R. R., Brookfield, N. S .... Dec. 3, 1897
Magee, W. H., PH. D., Annapolis, N. S .... Nov. 29, 1894
Matheson, W. G., New Glasgow, N. S .... Jan. 31, 1890
Payzant, E N., M. D., Wolfville, N. S .... April 8, 1902
Pineo, Avard V., LL. B., Kentville, N. S .... Nov. 5, 1901
*Reid, A. P., M. D., L. R. C S., Middleton, Annapolis Co., N. S .... Jan. 31, 1890
*Robinson, C. B., B.A., New York Botanical Garden, New York, U. S. A.. Dec. 3, 1902
*Rosborough, Rev. James, Musquodoboit Harbour, N. S .... Nov. 29, 1894

*Life Members.

Date of Admission.

Russell, Prof. Lee, B. S., Worcester, Mass.............................Dec. 3, 1896
Sawyer, Prof. Everett W., Acadia College, Wolfville, N. S...............Feb. 6, 1901

CORRESPONDING MEMBERS.

Ami, Henry M., D. SC., F. G. S., F R. S. C., Geological Survey, Ottawa, Ontario ....Jan. 2, 1892
Bailey, Prof. L. W., PH. D., LL. D., F. R. S. C., University of New Brunswick, Fredericton, N. B..Jan. 6, 1890
Ball, Rev. E. H., Tangier, N. S.......................................Nov. 29, 1871
Bethune, Rev. Charles J. S., M. A., D. C. L., F. R. S. C, Ontario Agricultural College, Guelph, Ont.....................................Dec. 29, 1868
Cox, Philip, B. SC., PH. D., Chatham, N. B.............................Dec. 3, 1902
Dobie, W. Henry, M. D., Chester, England...............................Dec. 3, 1897
Ells, R. W., LL. D., F. G. S. A., F. R. S. C., Geological Survey, Ottawa, Ont..Jan. 2, 1891
Faribault, E. Rodolphe, B. A., B. SC., Geological Survey of Canada, Ottawa; Assoc. Memb., March 6, 1888.....................................Dec. 3, 1902
Fletcher, Hugh, B. A., Geological Survey, Ottawa, Ontario ....March 3, 1891
Fletcher, James, LL. D., F. L. S, F. R. S. C., Entomologist and Botanist, Central Exp. Farm, Ottawa, Ontario ....March 2, 1897
Ganong, Prof. W. F., B. A., PH. D., Smith College, Northampton, Mass., U. S. A ....Jan. 6, 1890
Hardy, Maj.-General Campbell, R. A., Dover, England.....................Oct. 30, 1903
Harrington, W. Hague, F. R. S. C., Post Office Department, Ottawa ......May 5, 1896
Hay, George U., D. SC, F. R. S. C., St. John, N. B.......................Dec. 3, 1902
Litton, Robert T., F. G. S., Melbourne, Australia........................May 5, 1892
McSwain, John, Charlottetown, P. E. I...................................Dec. 3, 1902
Matthew, G. F., M. A., D. SC., F. R. S. C., St. John, N. B ....Jan. 6, 1890
Maury, Rev. Mytton, D. D., Ithaca, N. Y., U. S. A.......................Nov. 30, 1891
Peter, Rev. Brother Junian, Fall River, Mass., U. S. A..................Dec. 12, 1898
Pickford, Charles, Halifax..March 2, 1900
Prest, Walter Henry, M. E., Webbwood, Ont; Assoc. Memb., Nov. 29. 1894, Nov. 2 1900
Prichard, Arthur H. Cooper, Boston, Mass................................Dec. 4, 1901
Prince, Prof. E. E., Commissioner and General Inspector of Fisheries, Ottawa, Ontario ....Jan. 5, 1897
Smith, Hon. Everett, Portland, Maine, U. S. A ....Mar. 31, 1890
Weston, Thomas C., F. G. S. A., Ottawa, Ontario ....May 12, 1877

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* Life Members.

LIST OF PRESIDENTS

OF THE NOVA SCOTIAN INSTITUTE OF NATURAL SCIENCE, AFTERWARDS THE NOVA SCOTIAN INSTITUTE OF SCIENCE, SINCE ITS FOUNDATION IN 1862.

	Term of Office.		
Hon. Philip Carteret Hill, D. C. L.	31 Dec. 1862	to	26 Oct. 1863
John Matthew Jones, F. L. S., F. R. S. C.	26 Oct. 1863	"	8 Oct. 1873
John Bernard Gilpin, M. A., M. D., M. R. C. S.	8 Oct. 1873	"	9 Oct. 1878
William Gossip	9 Oct. 1878	"	13 Oct. 1880
John Somers, M. D.	13 Oct. 1880	"	26 Oct. 1883
Robert Morrow	26 Oct. 1883	"	21 Oct. 1885
John Somers, M. D.	21 Oct. 1885	"	10 Oct. 1888
Prof. James Gordon MacGregor, M. A., D. SC., F.R.S., F.R.S.C.	10 Oct. 1888	"	9 Nov. 1891
Martin Murphy, C. E., D. SC., I. S. O.	9 Nov. 1891	"	8 Nov. 1893
Prof. George Lawson, PH. D., LL. D., F. I. C., F. R. S. C.	8 Nov. 1893	"	10 Nov. 1895
Edwin Gilpin, Jr., M. A., LL. D., D. SC., F. G. S., F. R. S. C., I.S.O.	18 Nov. 1895	"	8 Nov. 1897
Alexander McKay	8 Nov. 1897	"	20 Nov. 1899
Alexander Howard MacKay, B. A., B. SC., LL. D., F. R. S. C.	20 Nov. 1899	"	24 Nov. 1902
Henry Skeffington Poole, M. A., D. SC., A. R. S. M., F. G. S., F. R. S. C.	24 Nov. 1902	"	18 Oct. 1905
Francis William Whitney Doane, C. E.	18 Oct. 1905	"	11 Nov. 1907
Prof. Ebenezer MacKay, PH. D.	11 Nov. 1907	"	———

NOTE—Since 1879 the presidents of the Institute have been *ex-officio* Fellows of the Royal Microscopical Society.

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(Roman numerals refer to the Proceedings; Arabic numerals to the Transactions.)

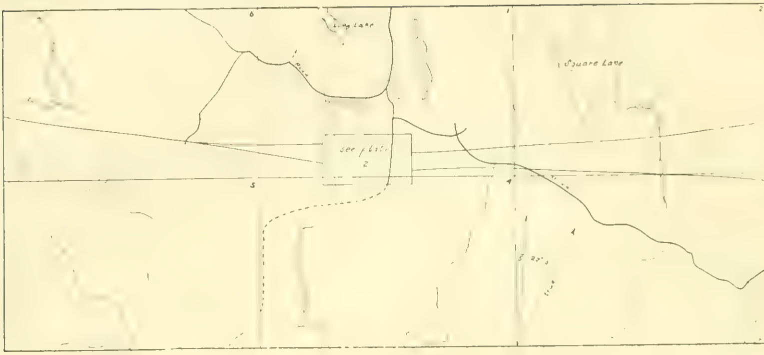


Fig. a.

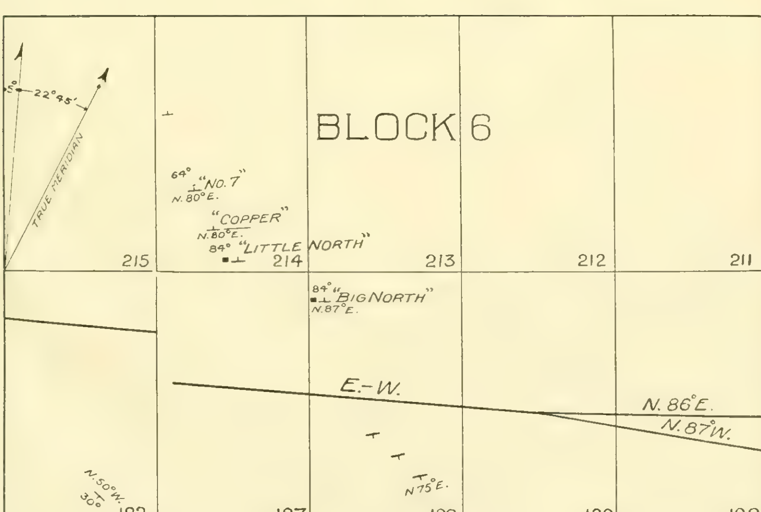
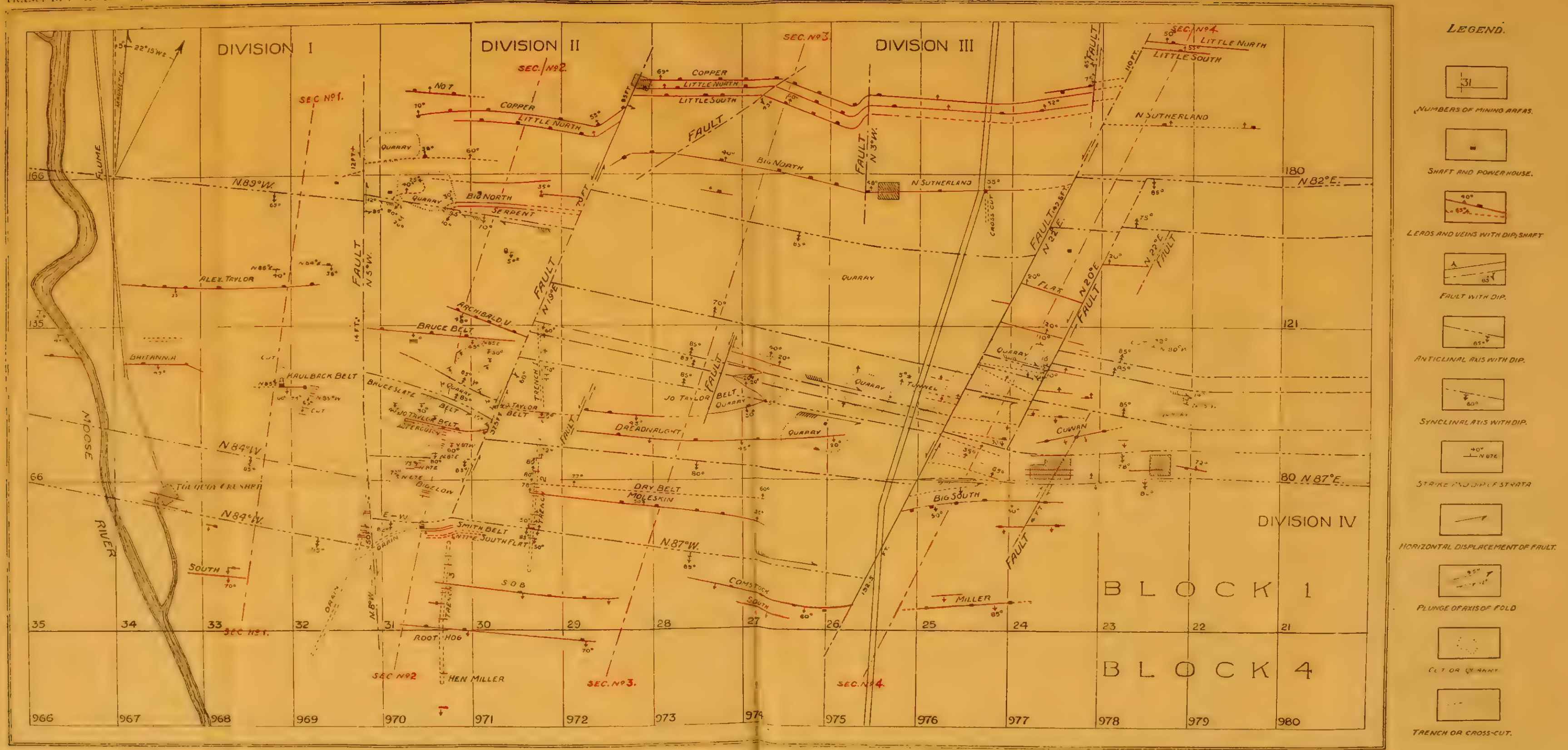
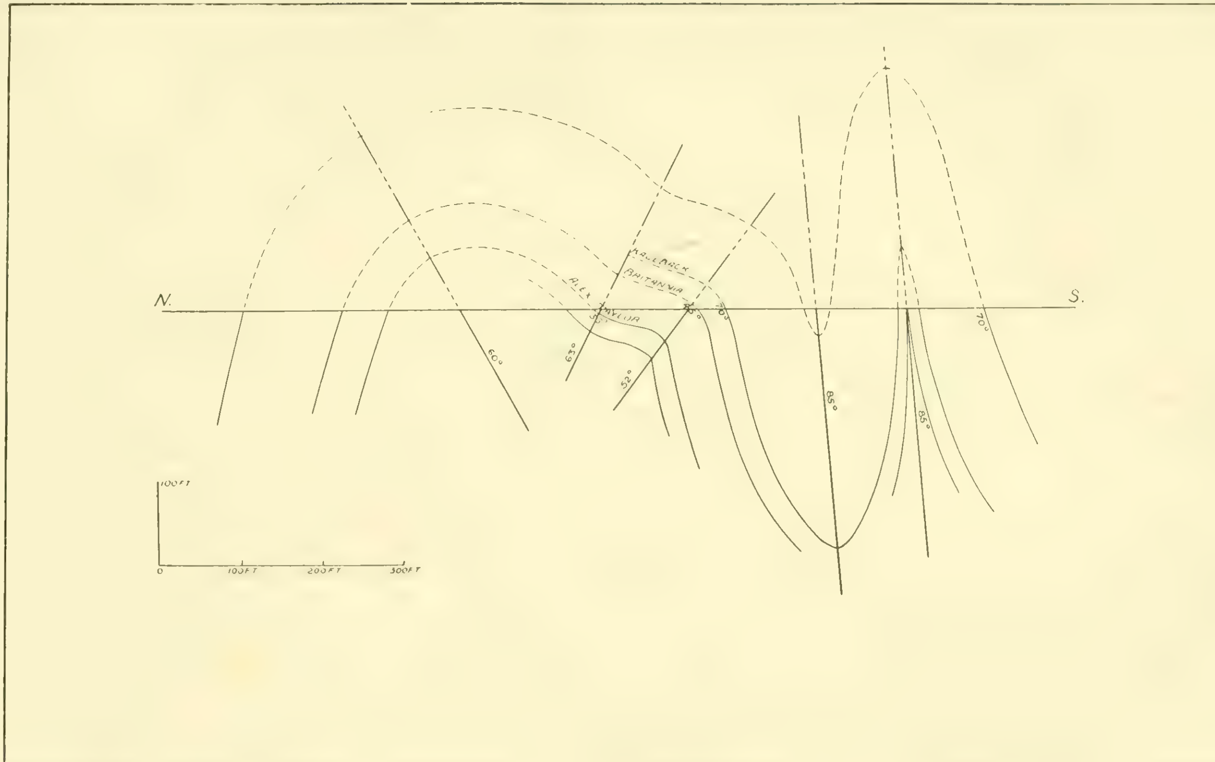
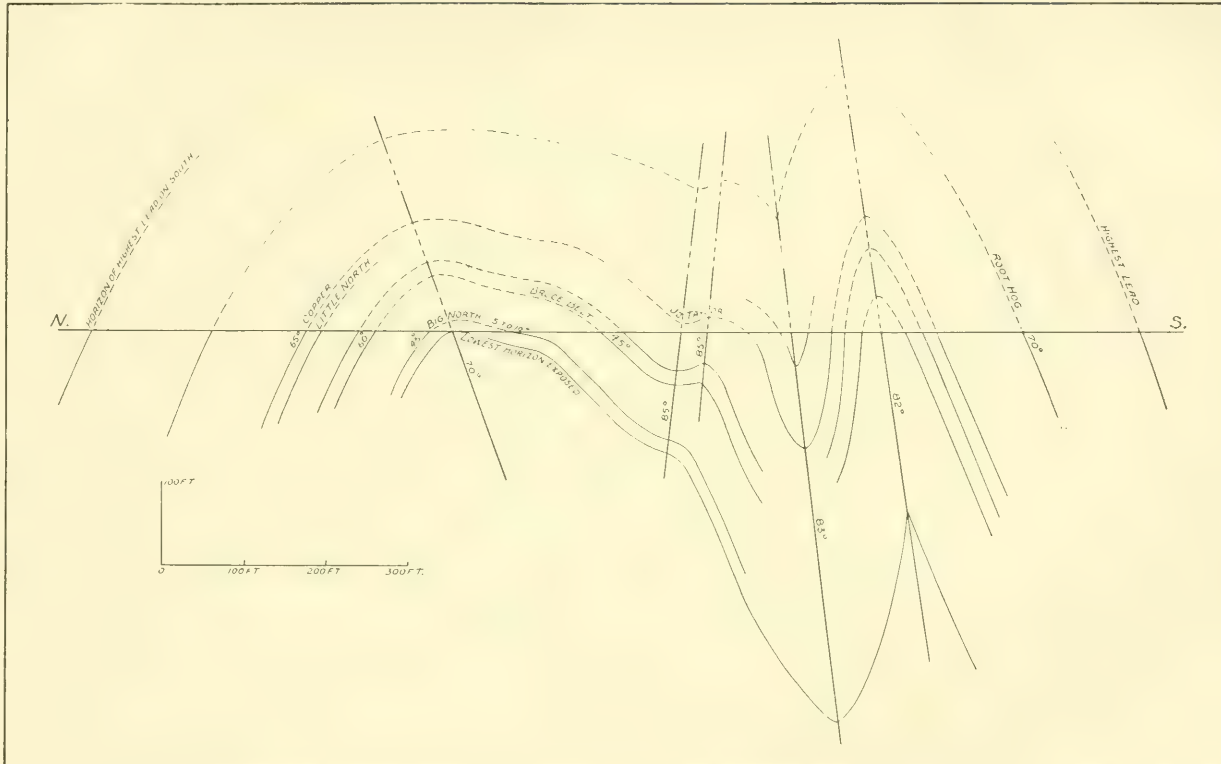
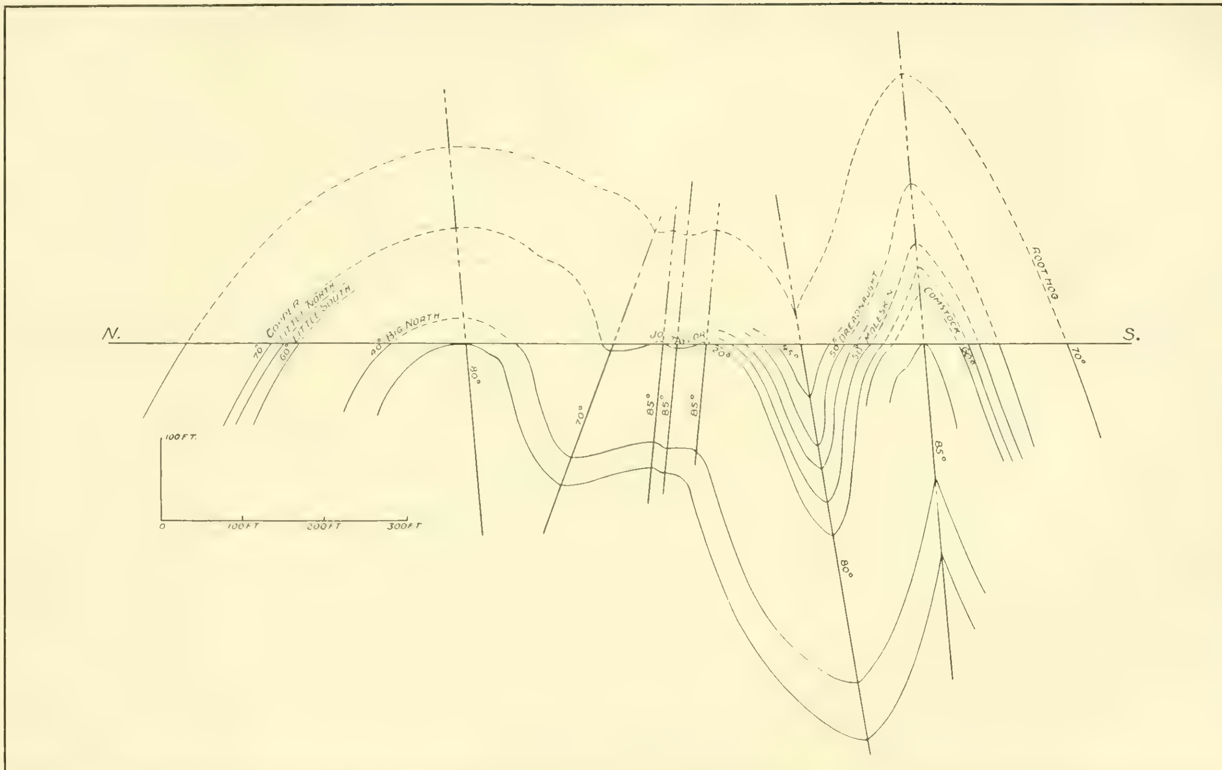

5°
22°45'
TRUE MERIDIAN
BLOCK 6
64°
"NO. 7"
N. 80° E.
"COPPER"
N. 80° E.
84° "LITTLE NORTH"
215
214
213
212
211
84° "BIG NORTH"
N. 87° E.
E.-W.
N. 86° E.
N. 87° W.
N. 50° W.
30°
N 75° E.
182
187
188
189
190

Fig. b.


DIVISION I
DIVISION II
DIVISION III
DIVISION IV
BLOCK 1
BLOCK 4
SEC. Nº 1.
SEC. Nº 2.
SEC. Nº 3.
SEC. Nº 4.
FAULT
FLUME
NOOSE RIVER
COPPER
LITTLE NORTH
LITTLE SOUTH
BIG NORTH
N SUTHERLAND
SERPENT
QUARRY
ALEX. TAYLOR
BRUCE BELT
ARCHIBALD V.
BRITANNIA
KAULBACK BELT
BRUCE SLATE
JO TAYLOR BELT
DREADNAUGHT
DRY BELT
MOLESKIN
SMITH BELT
SOB
COMSTOCK
SOUTH
ROOT HOG
HEN MILLER
MILLER
BIG SOUTH
CUWAN
FLAT
TUNNEL
TRENCH
N.89°W.
N.84°W.
N.87°W.
N 82°E.
N 87°E.
LEGEND.
NUMBERS OF MINING AREAS.
SHAFT AND POWER HOUSE.
LEADS AND VEINS WITH DIP; SHAFT
FAULT WITH DIP.
ANTICLINAL AXIS WITH DIP.
SYNCLINAL AXIS WITH DIP.
HORIZONTAL DISPLACEMENT OF FAULT.
PLUNGE OF AXIS OF FOLD
TRENCH OR CROSS-CUT.


N.
S.
70°
85°
85°
70°
63°
52°
60°
BRITANNIA
ALEX TAYLOR
100 FT
0
100 FT
200 FT
300 FT


N.
S.
HORIZON OF HIGHEST LEAD ON SOUTH
COPPER
LITTLE NORTH
BIG NORTH
LOWEST HORIZON EXPOSED
BRACE BELT
ROOT HOG
HIGHEST LEAD
65°
60°
45°
70°
75°
85°
85°
83°
82°
70°
100 FT
0
100 FT
200 FT
300 FT.



N.
S.
ROOT HOG
COMSTOCK
MOLESK N
DREADNAUGHT
BIG NORTH
COOPER
LITTLE NORTH
LITTLE SOUTH
85°
80°
70°
100 FT.
0
100 FT
200 FT
300 FT


N.
S.
85°
75°
100 FT.
0

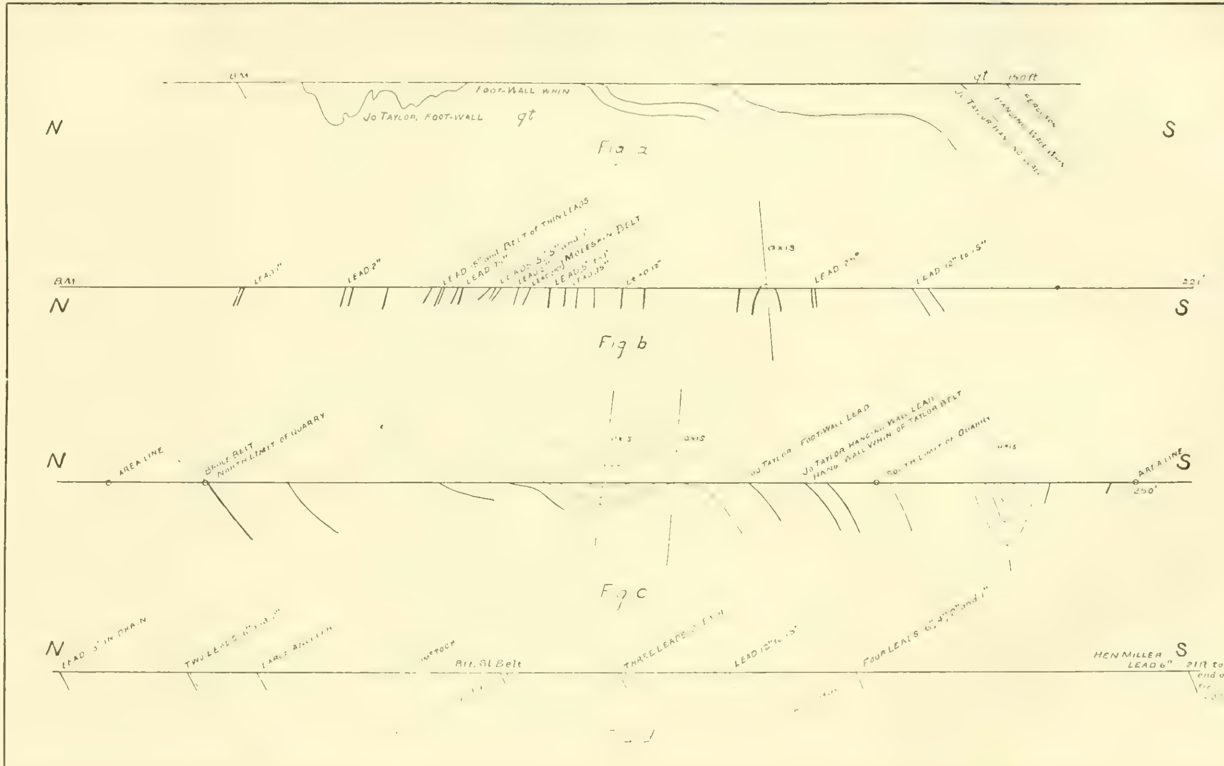

N
S
FOOT-WALL WHIN
JO TAYLOR, FOOT-WALL
gt
150 ft
Fig a
LEAD 2"
LEAD 15" and BELT of THIN LEADS
MOLESKIN BELT
AXIS
LEAD 12" to 15"
221'
Fig b
AREA LINE
NORTH LIMIT of QUARRY
AXIS
JO TAYLOR FOOT-WALL LEAD
JO TAYLOR HANGING WALL LEAD
HANG WALL WHIN OF TAYLOR BELT
SOUTH LIMIT of QUARRY
250'
Fig c
Bit. Sl Belt
HEN MILLER
LEAD 6"
21 ft to
end of

Fig a.

Fig. b.

Fig. c.

FIG a

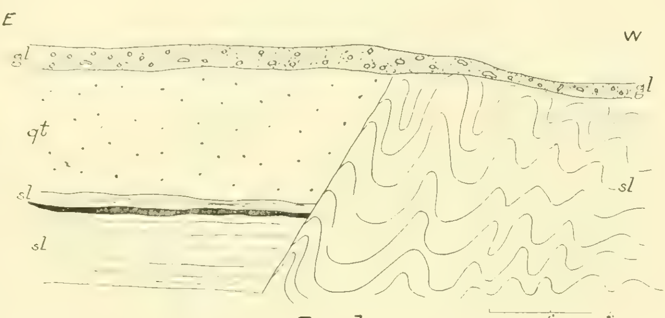


FIG. b

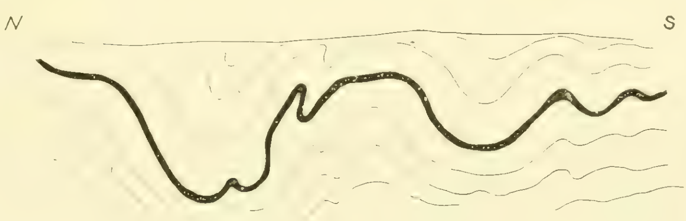
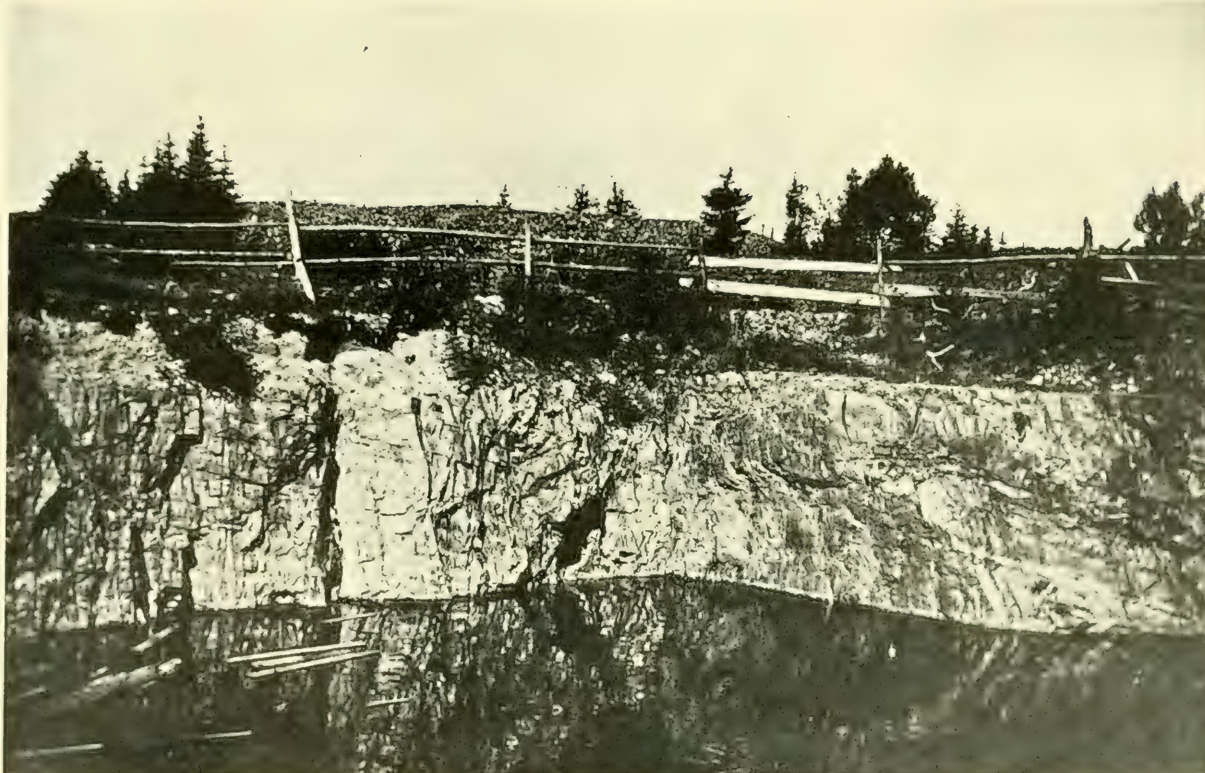


FIG c



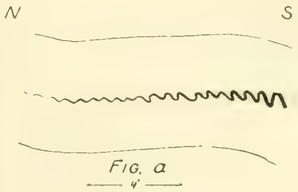


Fig. a

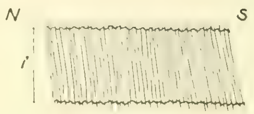


Fig b

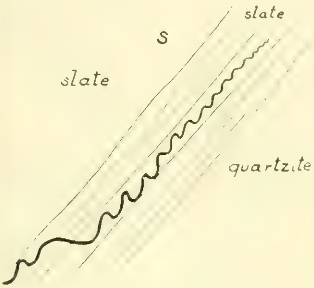


Fig C

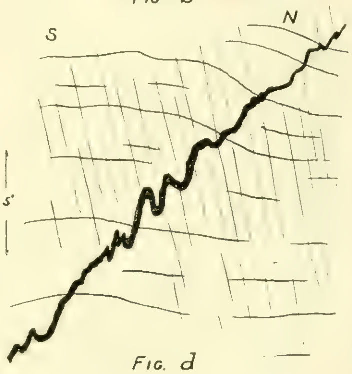


Fig. d

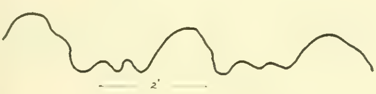


Fig e

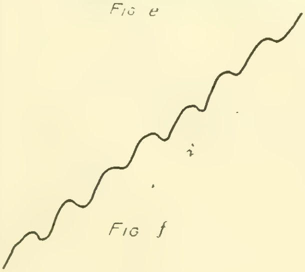


Fig f

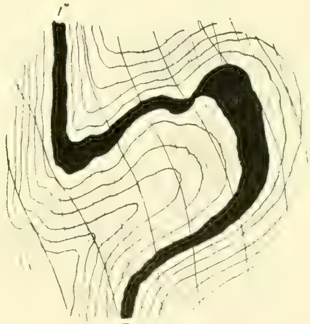


Fig. G

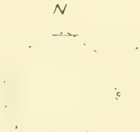


Fig h

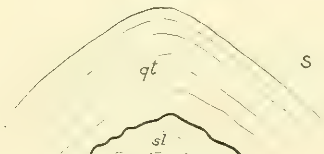
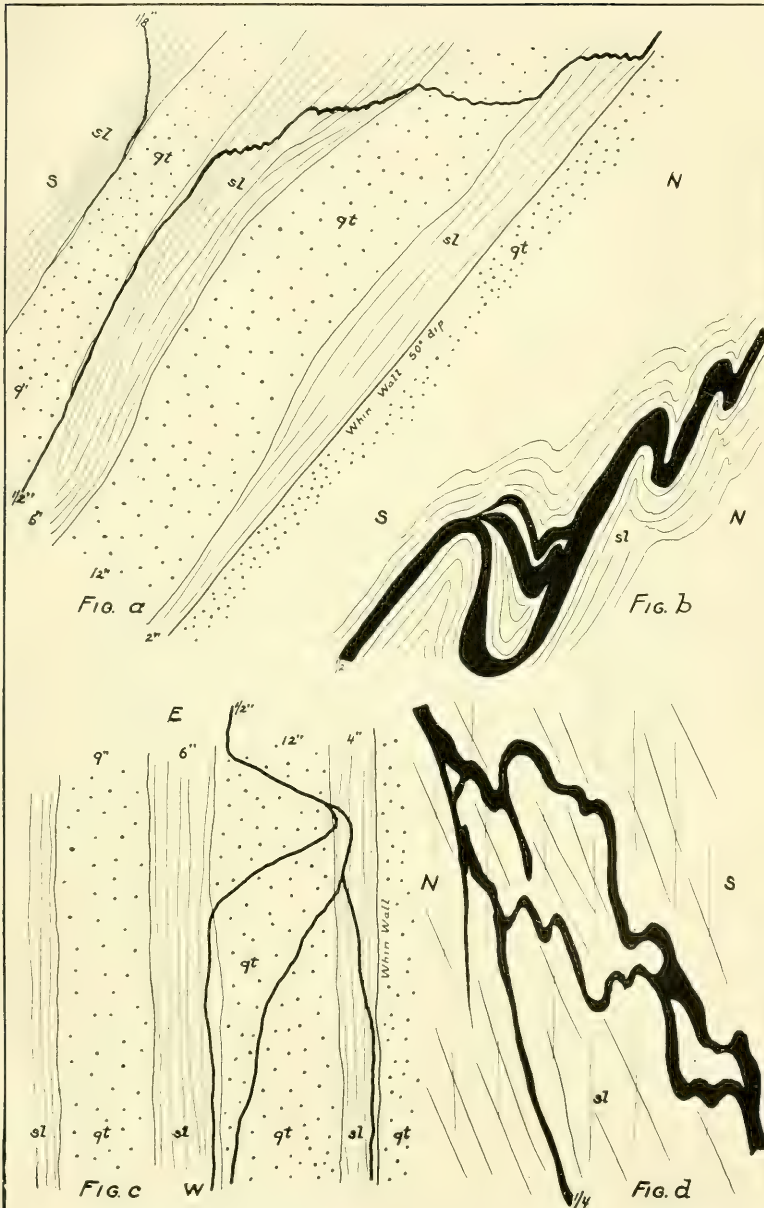
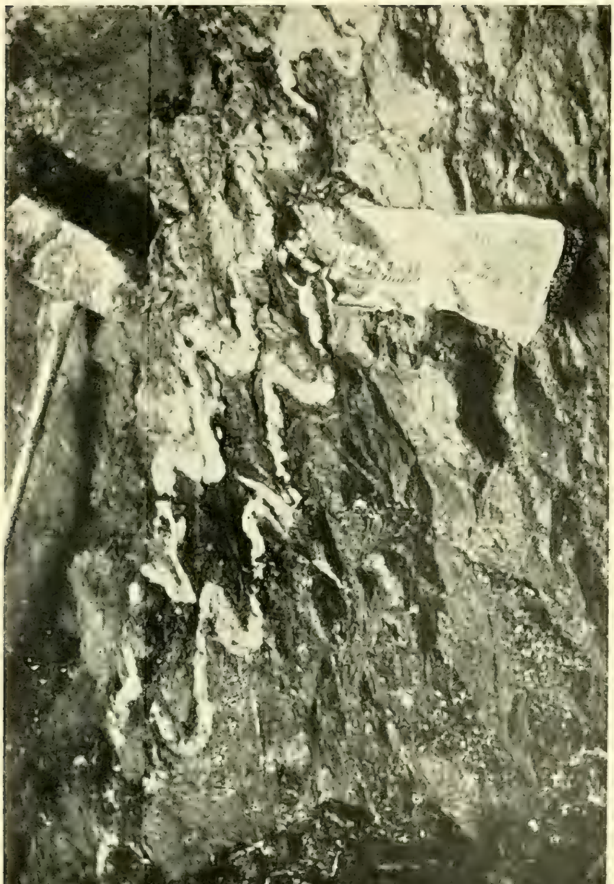
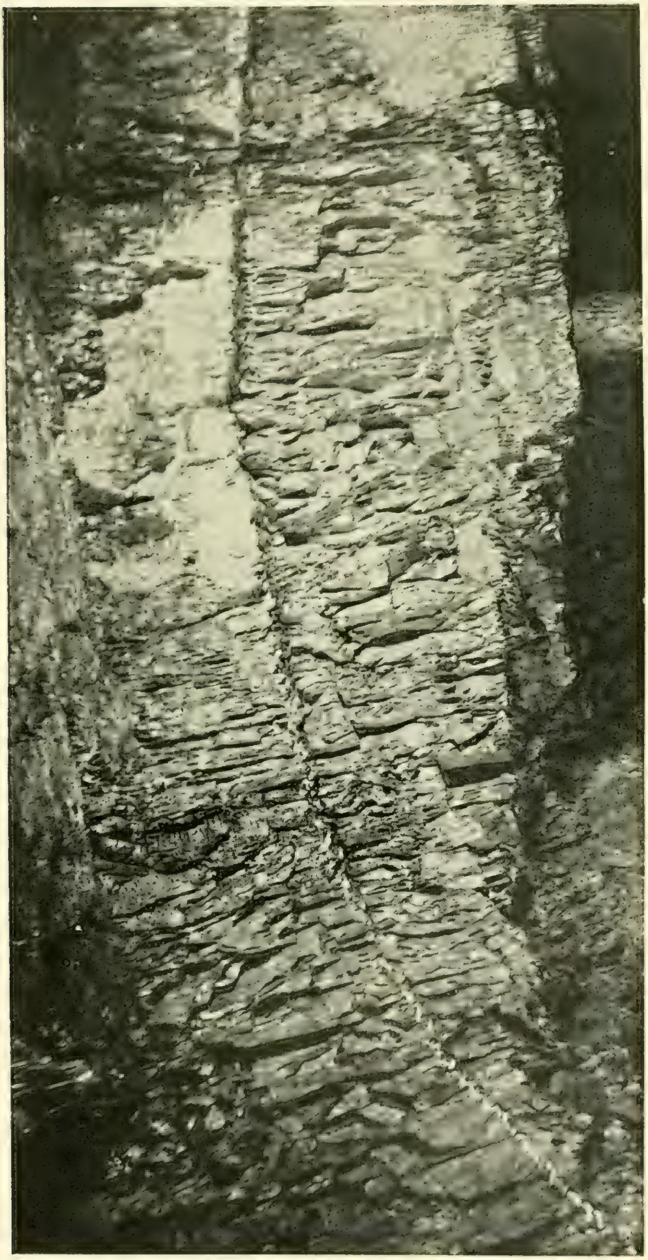
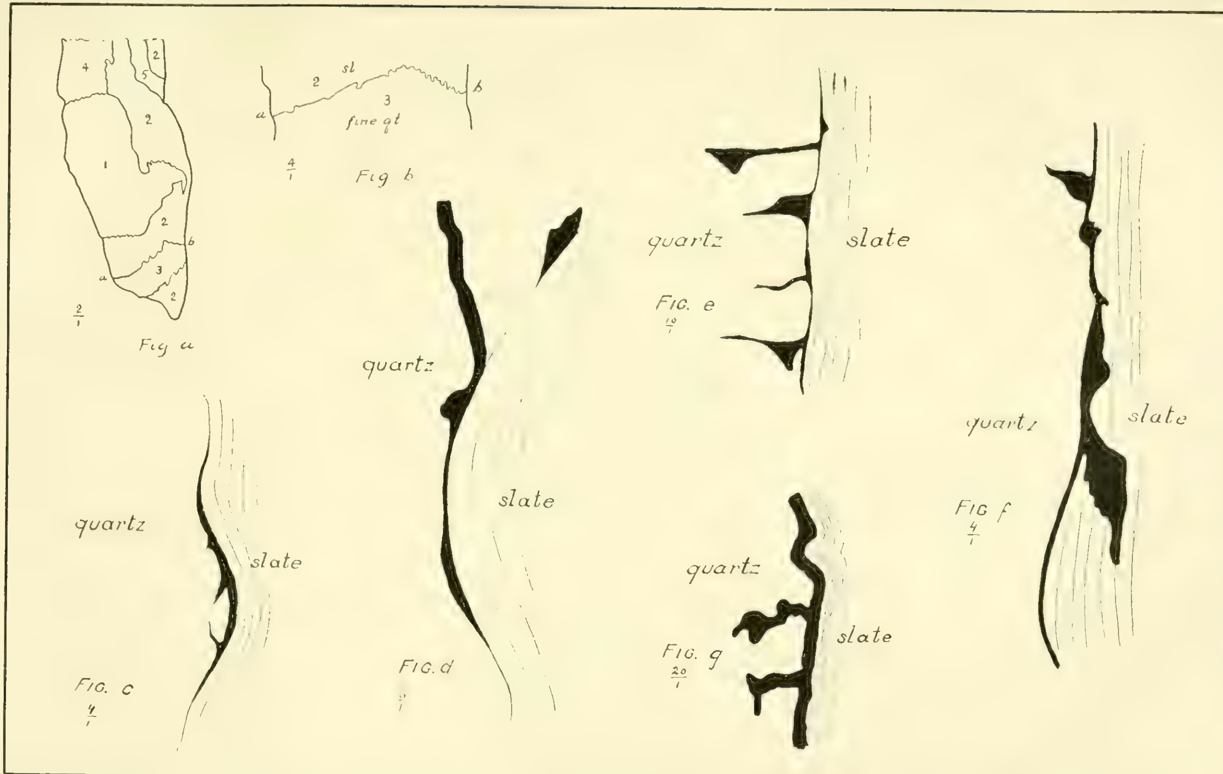


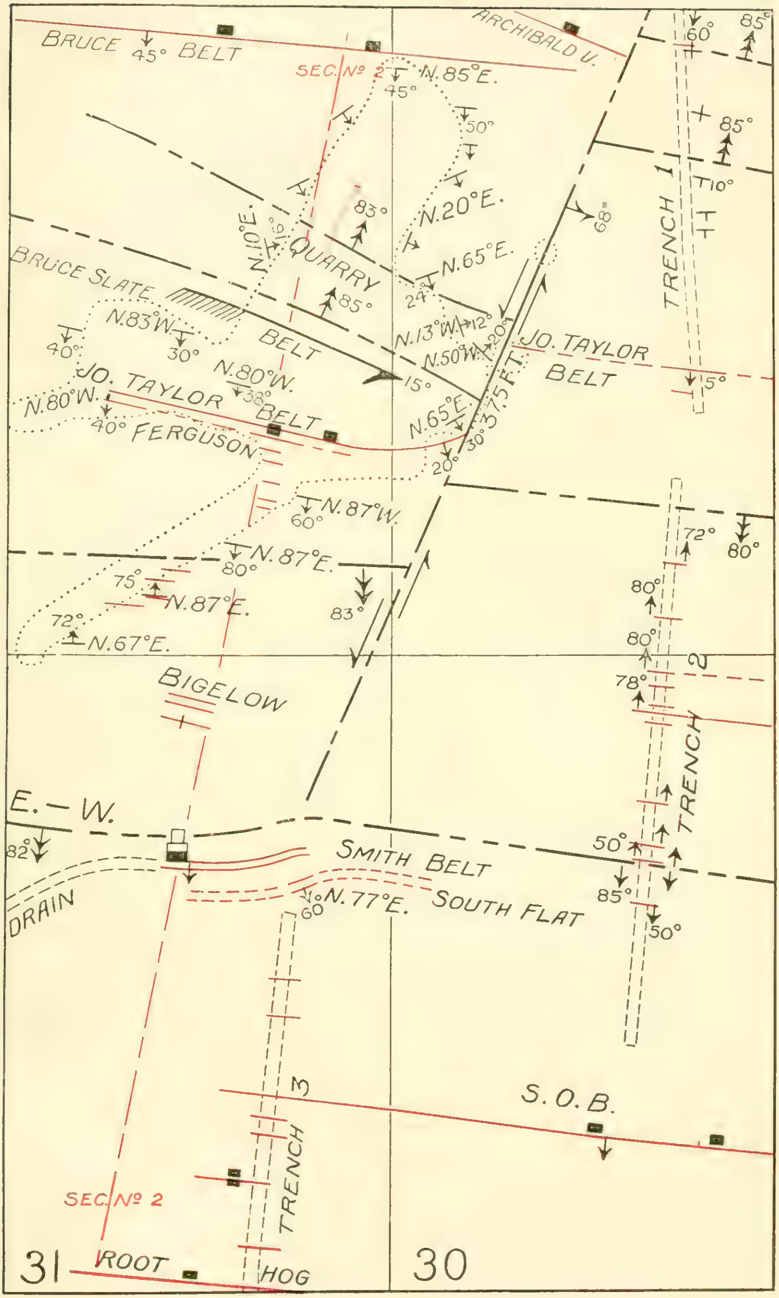
Fig. i

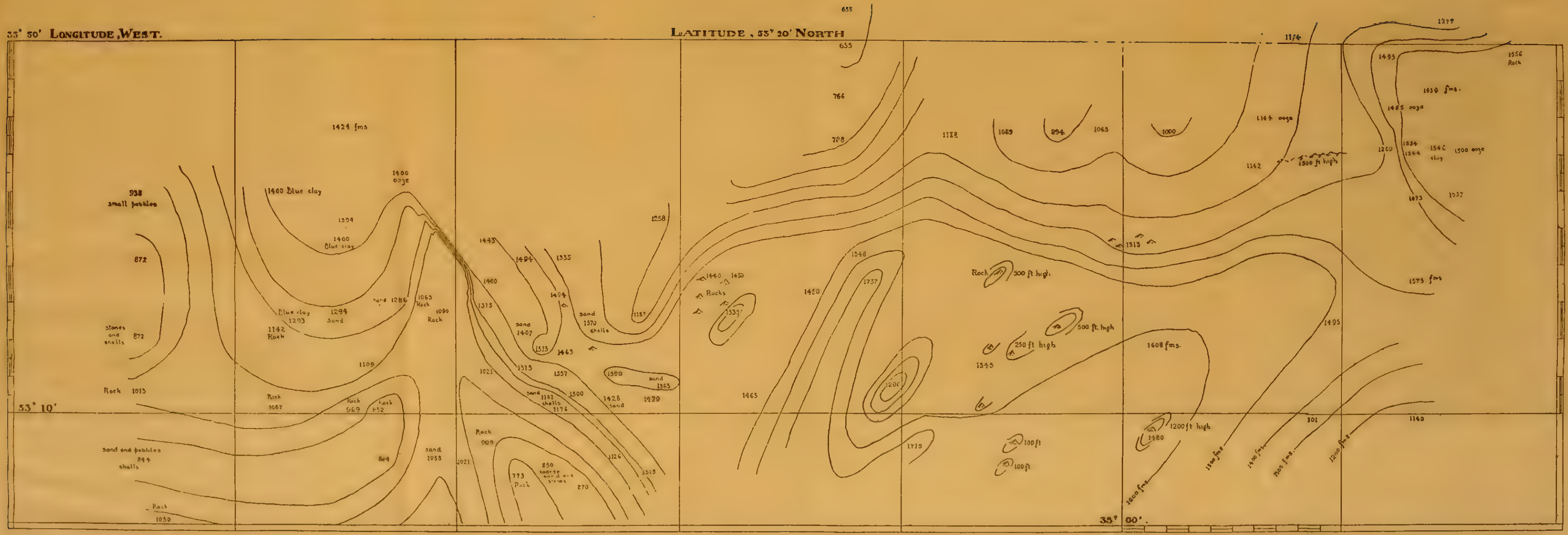

1/8"
sl
qt
S
sl
N
qt
sl
qt
Whin Wall 50° dip
9"
1/2"
6"
12"
2"
Fig. a
S
N
sl
Fig. b
1/2
E
1/2"
12"
4"
9"
6"
N
S
qt
Whin Wall
sl
sl qt sl qt sl qt
Fig. c
W
1/4
Fig. d






4
2
5
2
1
2
3
2
a
b
2/1
Fig a
2
sl
3
fine qt
a
b
4/1
Fig b
quartz
slate
FIG. c
4/1
quartz
slate
FIG. d
quartz
slate
FIG. e
10/1
quartz
slate
FIG. g
20/1
quartz
slate
FIG f
4/1

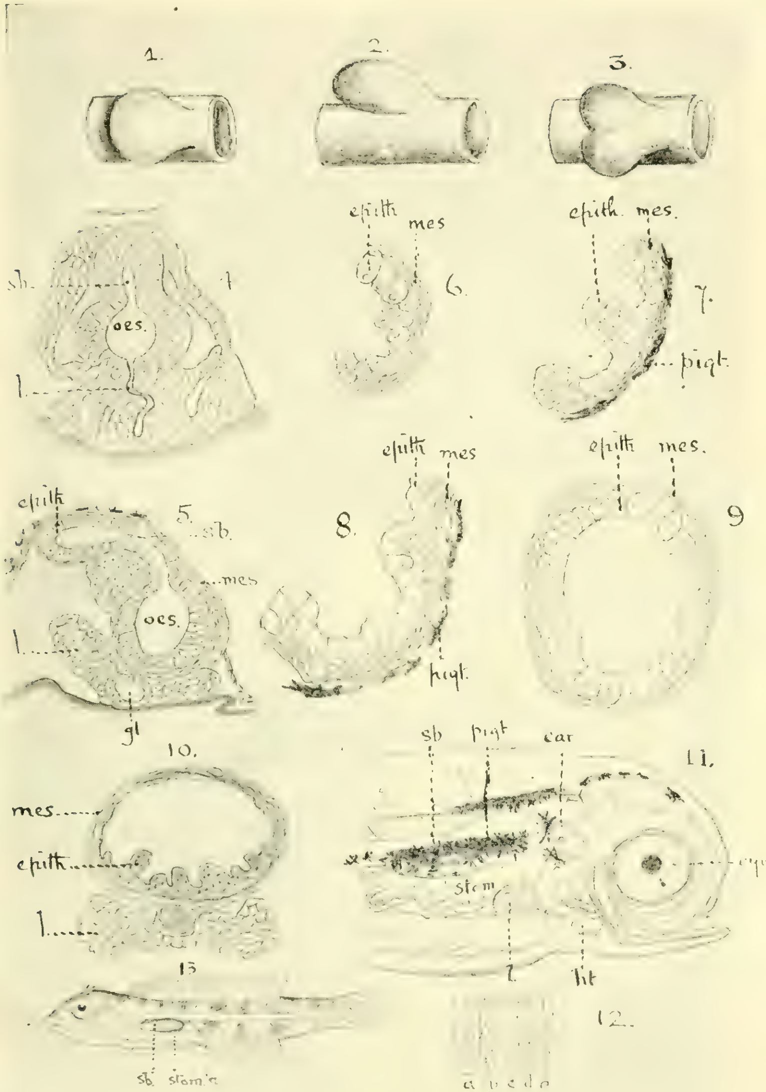

BRUCE BELT
45°
ARCHIBALD U.
SEC. Nº 2
N.85°E.
45°
50°
N.20°E.
83°
N.10°E.
16°
QUARRY
N.65°E.
68°
TRENCH 1
85°
60°
10°
BRUCE SLATE BELT
85°
24°
N.83°W.
40°
30°
N.13°W.
12°
N.50°W.
20°
JO. TAYLOR BELT
375 FT.
15°
5°
N.80°W.
38°
JO. TAYLOR
N.80°W.
BELT
40° FERGUSON
N.65°E.
30°
20°
N.87°W.
60°
72°
80°
N.87°E.
80°
83°
75°
N.87°E.
80°
80°
72°
N.67°E.
2
78°
BIGELOW
TRENCH
E.—W.
82°
50°
SMITH BELT
DRAIN
N.77°E.
60
SOUTH FLAT
85°
50°
3
S. O. B.
TRENCH
SEC. Nº 2
31
ROOT
HOG
30



To face p. 198.

CHART ILLUSTRATING DR. POOLE'S PAPER ON "THE SUNKEN LAND OF BUS (LAT. 35 W., LON. 53 N.)"

Face p. 226.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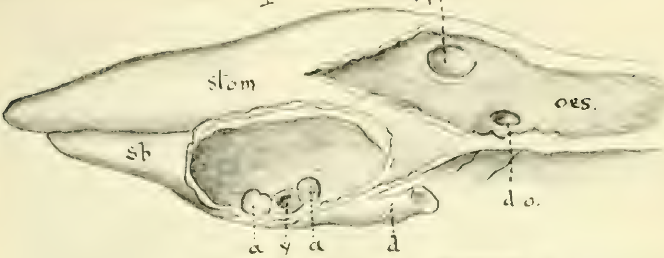

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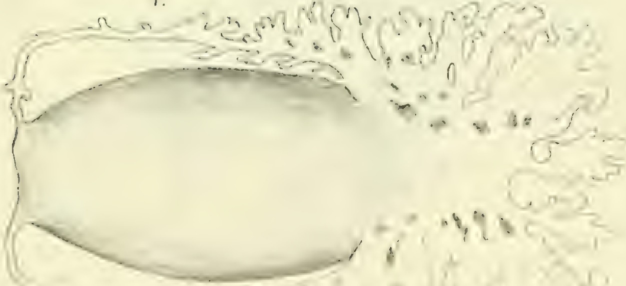
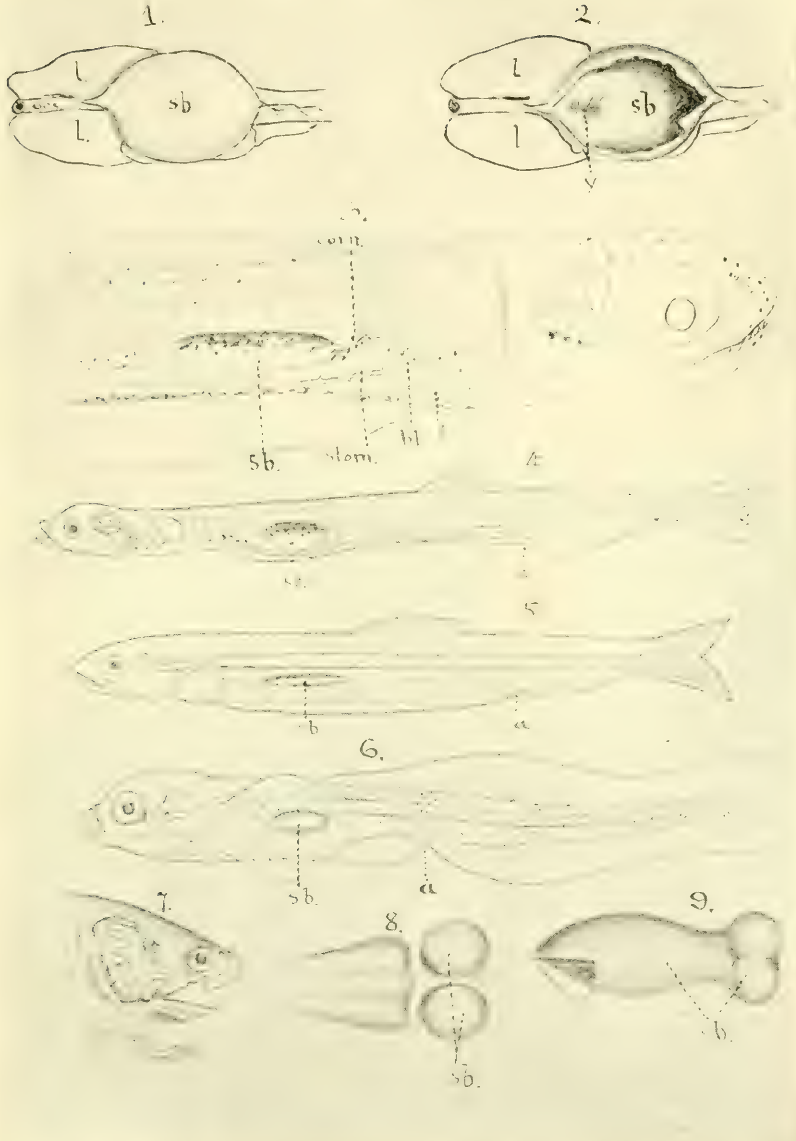
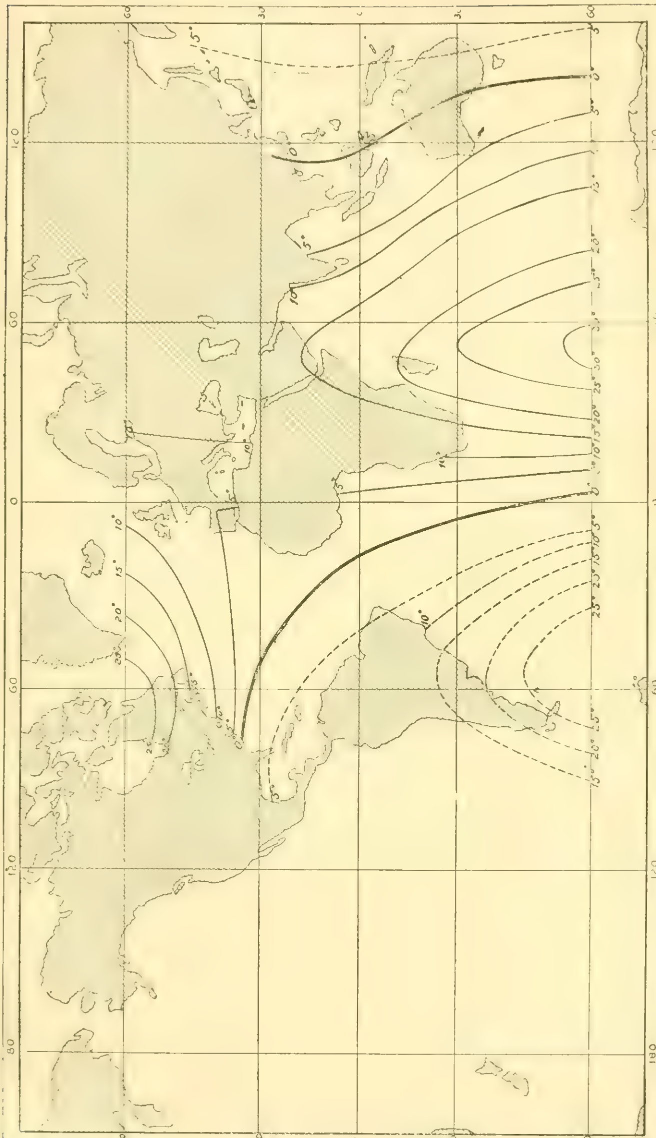


Face p. 226.



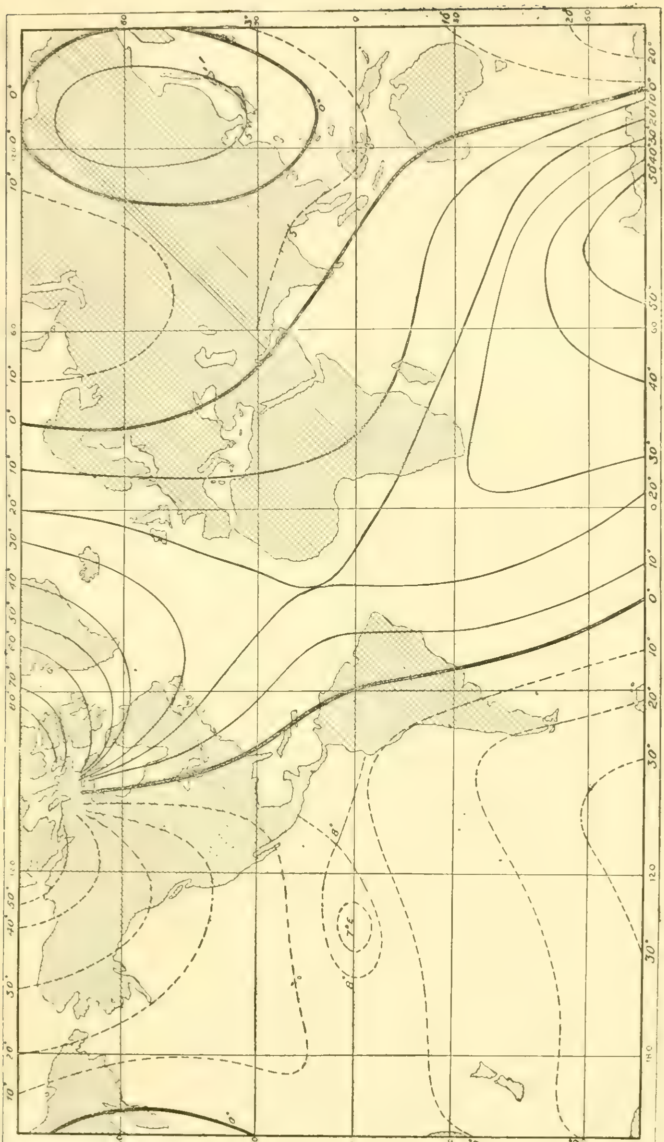
Face p. 226.



ISOGONIC CHART FOR 1702 (HALLEY).

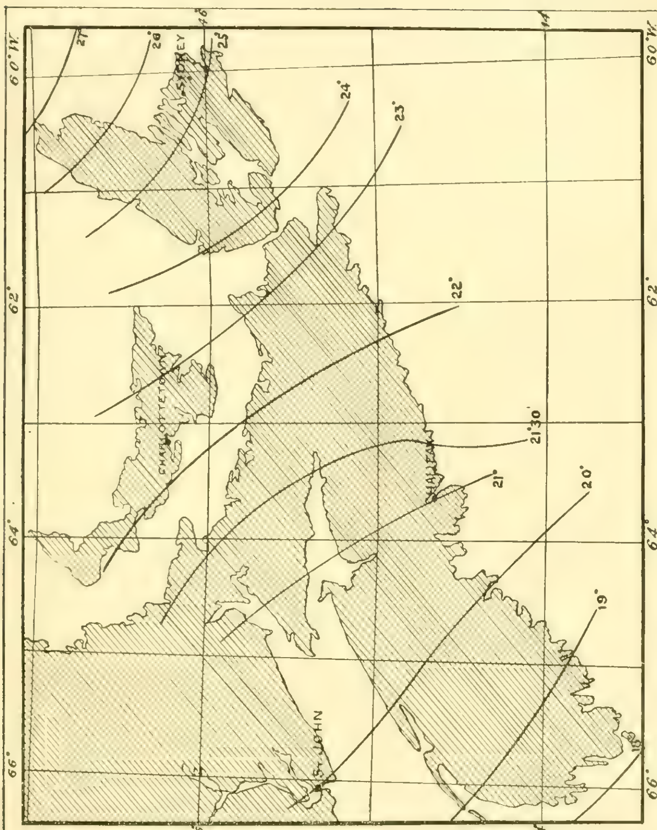
(Broken Lines indicate Eastern Declination.)

From U. S. Magnetic Declination Tables, 1902.



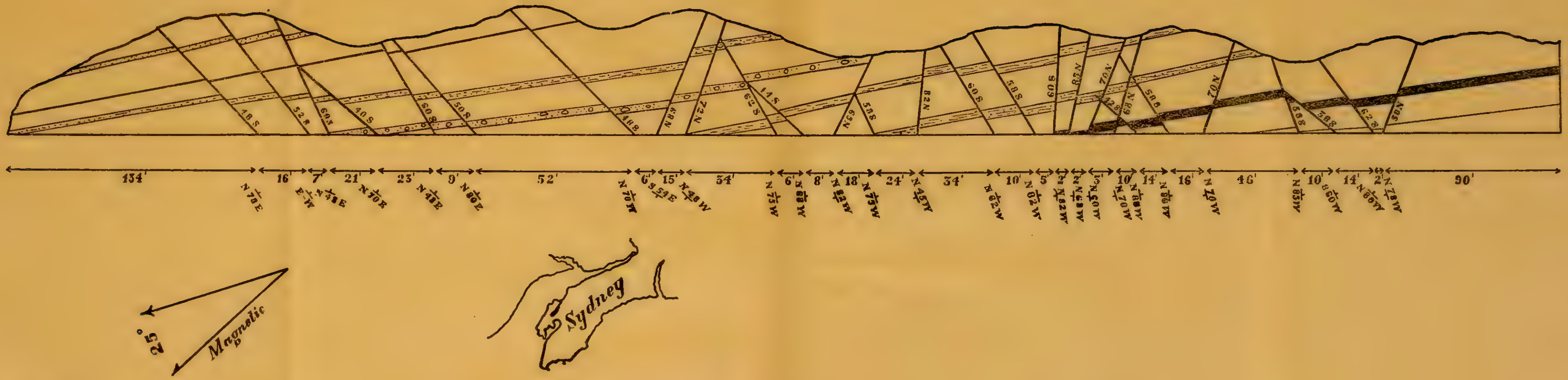
ISOGONIC CHART FOR 1905 (BRITISH ADMIRALTY).

(Broken Lines indicate Eastern Declination.)



APPROXIMATE POSITIONS OF LINES OF EQUAL DECLINATION IN NOVA SCOTIA IN THE YEAR 1904.

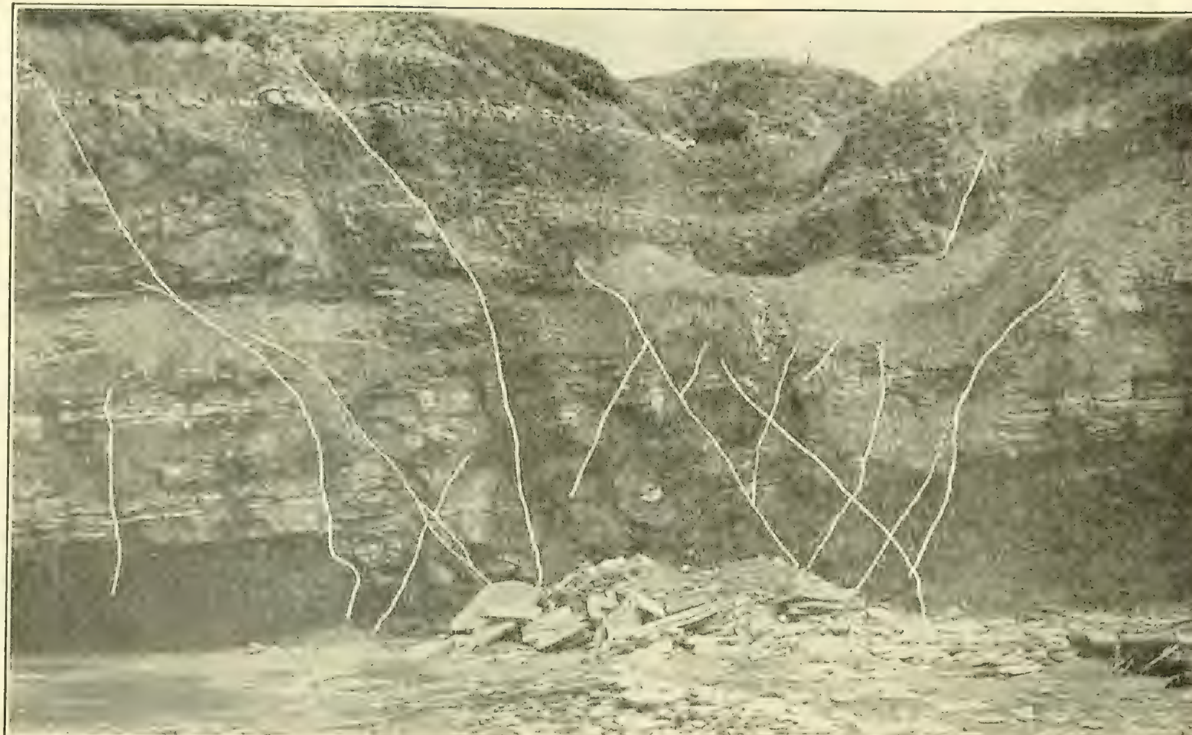
(Fault lines etched in white.)



To face p. 261.

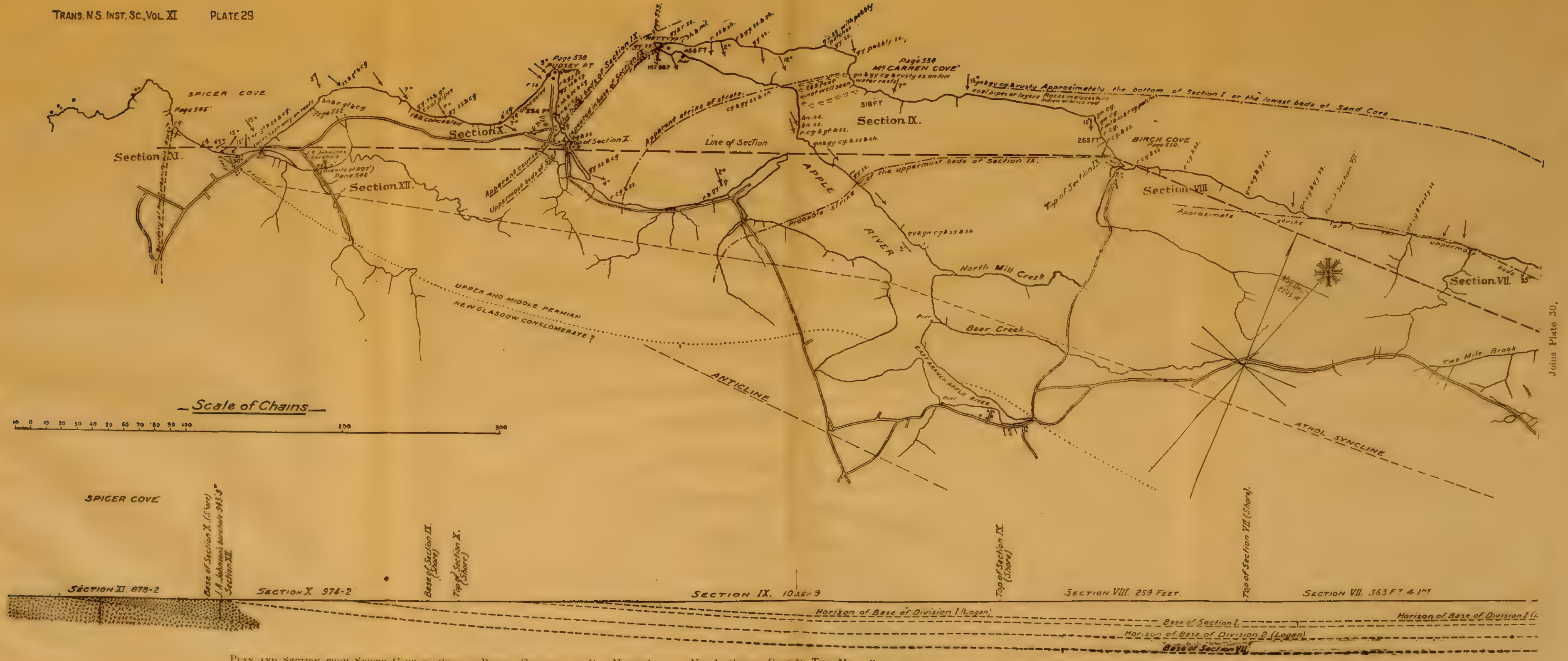
DIAGRAMMATIC SECTION OF THE FAULTED ZONE IN THE LOWER CARBONIFEROUS STRATA OF BATTERY POINT, SYDNEY, C. B.

[DOT AT END OF POINT IN INDEX MAP SHOWS GENERAL LOCATION.]

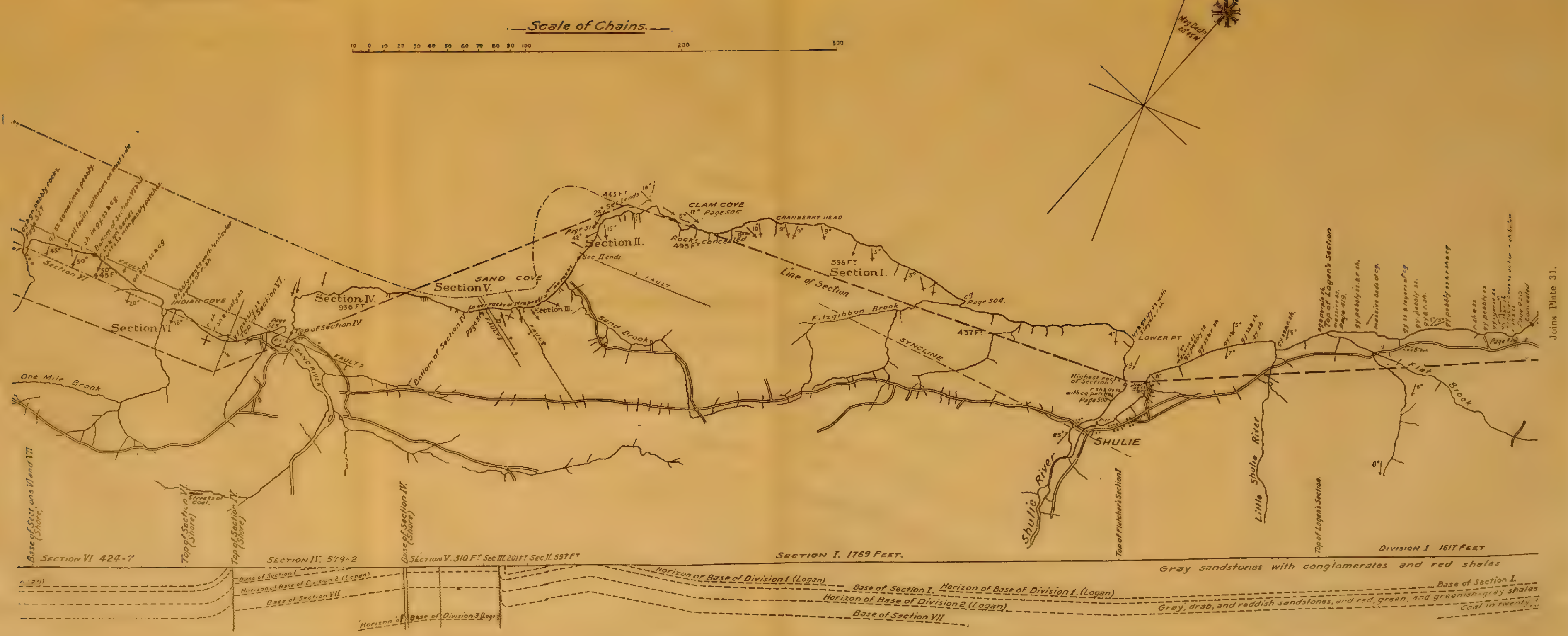


Most broken portion of the section showing details of faults, Battery Point, Sydney, C. B.

(Fault lines etched in white.)



PLAN AND SECTION FROM SPICER COVE TO SEAMAN BROOK, CUMBERLAND CO., NOVA SCOTIA.—No. 1 (SPICER COVE TO TWO MILE BROOK). *(To illustrate paper by Sir William E. Logan and Hugh Fletcher on Carboniferous Rocks in Cumberland Co.)*



PLAN AND SECTION FROM SPICER COVE TO SEAMAN BROOK, CUMBERLAND CO., NOVA SCOTIA.—No. 2 (TWO MILE BROOK TO LEARY RAFT BROOK). *(To illustrate paper by Sir William E. Logan and Hugh Fletcher on Carboniferous Rocks in Cumberland County.)*

Plan and Section from Spicer Cove to Seaman Brook, Cumberland Co., Nova Scotia.—No. 3 (Leary Raft Brook to Seaman Brook) *(To illustrate paper by Sir William E. Logan and Hugh Fletcher on Carboniferous Rocks in Cumberland Co.)*